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Investment Casting

When the lost-wax process was developed during the war, its products became known as precision castings. The output was mainly turbine blades and components required to possess very close dimensional tolerances and made in materials difficult, if not impossible, to manufacture by any other means. We remember a prominent metallurgist asserting just after the establishment of the method, that this was not a process to be placed in the hands of the foundryman but, for success, should be retained in the hands of members of his profession. No greater mistake could have been made, for of all processes devoted to the manufacture of castings, this one is outstanding as needing control by high-grade foundry technicians.

Very recently we had the privilege of seeing a foundry specially designed for the production of what should be called "investment" castings. We stress this because quite a high percentage of the castings being made carried no particular restriction as to dimensional tolerances. Included in this category was a very wide range of surgical instruments cast in stainless steel. It would appear that there is a real scarcity of craftsmen capable of making these by the traditional processes. Moreover for finish and suitability for the often horrible jobs they have to perform we assert that their quality is impeccable. The making of turbine blades has achieved a standard of workmanship comparable with the best seen in other sections of our industry From the working drawings a multiplicity of cross-sections of the blade are taken all along the length, and the contours are reproduced in sheet-metal sections. Their finishing is carried out in an apparatus which magnifies the component about twenty times. As each of the segments is finished it is placed flush at the side of its fellow in a precision-machined box and thereby the complete model of the blade is built up.

The foundry we visited, to the management of which we tender our thanks, was D. Napier & Son, Limited, of Park Royal, London, carrying a staff of about 50 people. Plans are well advanced, however, for doubling the present size. A feature of much interest was the provision of about eight furnaces, mostly of the indirect-arc type, supplemented by a high-frequency plant. The elasticity of the melting process was extended by having numerous furnace bodies of different capacities and always reserving the same body for one particular alloy—thus eliminating the possible variable of contamination through lining absorption. The production rate is governed by the capacity of the continuous furnace used for the final heating of the stainless-steel canisters carrying the moulds, which it will be remembered are filled with metal by attaching them to the actual furnaces and inverting the assembly. In some cases, the moulds are placed on a spinning machine for casting so as to bestow the advantages to be gained from centrifugal pressures.

E

Investment Casting

With growth in size of this type of plant, the need for thought to be given to handling and storage becomes obvious, not so much in the actual processing or despatch, but rather from the receipt of the raw materials and their preparation for use by the foundry. The quantities now used and reused are not inconsiderable. When developing a "newish" system such as this or the "C" process, new types of machinery have to be installed. They may be designed by the foundries themselves, and after installation it is sometimes found that plant made for the chemical or large-scale catering industry is equally suitable. This shows how desirable it is that foundrymen should visit trade exhibitions not necessarily of direct interest to their work.

With the investment process, as has so often happened with others, exploitation reveals potentialities not initially envisaged, and nowadays production will include turbine blades, medical and dental instruments, components for sewing-machine, dairying, cast cutting tools and diverse industries. The making of investment castings, at one time showing signs of languishing, is now settling down to form an important and very interesting section of the foundry industry.

Correspondence

1949 FACTORY REPORT

To the Editor of the FOUNDRY TRADE JOURNAL

SIR,—We note from your editorial on the 1949 Factory Report that attention has been drawn to the rapid wearing away in foundries of concrete gangways when subjected to heavy traffic and to the consequent necessity of reinforcement. It is not perhaps sufficiently known that there is a very simple method of increasing the wear resistance of concrete flooring. This is by the incorporation of a suitably graded clean grey-iron powder into the surface concrete as it is laid.—Yours, etc.,

for George Cohen Sons & Company, Limited.

Broadway Chambers,
Hammersmith, London, W.6. FELIX LEVY,
March 21, 1951. *Director.*

[This letter has been slightly abridged.—*Editor.*]

Institute of Indian Foundrymen

We are pleased to announce the foundation of the Institute of Indian Foundrymen with offices at B-33 Ganesh Chandra Avenue, Calcutta 13. A council has been formed, with Mr. T. R. Gupta, B.Sc. (director, Jay Engineering Works, Limited, Dakkuria) as *president*. Mr. N. G. Chakrabarty, M.I.B.F. as *vice-president* and Mr. Arjan Vaswani, B.Sc. as *honorary secretary*.

The articles of association of which copies have reached us, show that it is a technical organisation modelled on the lines of the Institute of the British Foundrymen. We take this opportunity of wishing every success to the new Institute and congratulate the founders on the consummation of their endeavours.

Notes from the Branches

Scottish

The annual business meeting of the Scottish branch of the Institute of British Foundrymen was held in the Royal Technical College, Glasgow, on March 10, when the branch-president, Mr. James G. Arnott, was accompanied to the platform by the president of the Institute, Mr. J. J. Sheehan, the secretary, Mr. Tom Makemson, M.B.E., and Mr. S. A. Horton, hon. secretary of the East Midlands branch. The annual reports (already published) were approved and office-bearers for session 1951-52 were elected, after which the meeting was addressed by Mr. Sheehan and Mr. Makemson.

An announcement was made regarding the short paper competition, the winner of the first prize being Mr. G. D. McNair, of Leeds (formerly of Bathgate); Mr. Hal London, of Leven, was awarded second prize and Mr. William Pollock, third prize. The prizes were presented to the winners by Mr. Sheehan, who complimented the recipients on their successes.

After the formal business of the meeting had been concluded, Mr. Horton read a Paper on "Pattern Making as an Aid to Production, Moulding and Coremaking"; it was well received and a good discussion followed.

Dinner

In the evening, the branch dinner was held in the Grosvenor Restaurant, Glasgow, Mr. James G. Arnott again presiding. The toast of "the City and Corporation of Glasgow" was proposed by Mr. John Arnott and replied to by Bailie Edwin J. Donaldson, D.L., J.P. "The Institute" was proposed by Mr. William Barr, president of the West of Scotland Iron and Steel Institute, and replied to by Mr. Sheehan, and "the Scottish branch of the Institute" was proposed by Mr. S. A. Horton and replied to by Mr. James G. Arnott. Mr. Tom Makemson also spoke on the work of the branch and complimented the president and officers on its healthy condition. The musical section of the programme was under the direction of Mr. J. C. Dorsie, a member of the branch, who made his first appearance in this capacity some thirty-one years ago.

Australian Foundry Medals

The Wm. A. Gibson Medal, a new award donated by Mr. Gibson, the well-known Australian foundry engineer, has been won by Mr. Linsay McIntosh. The object of the award is to enhance the worth of the examinations held annually in foundry practice in Sydney. The terms of the award are:—

"A medal to be awarded annually to the student securing the best pass in the final stage of the foundry-technology course, subject to the following conditions—

(*a*) The successful student must have served an apprenticeship in ferrous or non-ferrous founding;

(*b*) the medal will only be awarded to a student whose work in all stages of the foundry-technology course has been of sufficient merit.

In the event of there being no eligible students completing the course in any year who have served an apprenticeship as required, a special prize will be awarded to the student securing the best pass in the final stage whose work in all stages has been of sufficient merit."

A second medal, the Irons Memorial Medal, was won by Mr. Bruce A. Morrison. This award is only available for a foundry apprentice once every five years; at other times it is reserved for different branches of engineering.

Running and Feeding of Castings*

By H. S. Farmer

Many foundrymen are acutely aware of the difficulties which confront those who attempt the design of runners and feeders to any particular casting. The variables are so numerous and the data available so conflicting that any light that can be thrown on this very practical subject is of some moment, especially if it promotes discussion which will clarify the practical approach and increase the ability to control foundry practice, thereby reducing scrap, which all founders are guilty of producing in varying degrees. It was in the light of these observations that what follows was written.

SPEAKING generally, there are two requirements in a runner system:—(1 Pouring speed, to fill the mould cavity as swiftly as possible, but controlled to prevent a passage of foreign bodies into the mould, and (2) distribution of the metal, in the mould, in such a manner as not to create turbulence, but to promote directional solidification towards the feeder.

The feeder head should fulfil three requirements:—(1) Be of such a volume as to contain sufficient liquid metal to compensate for volume contraction in the mould cavity during solidification of the casting; (2) contain sufficient heat to set up the necessary temperature gradient for directional solidification of the casting towards the reservoir of molten metal available in the feeder, and (3) feeder metal should remain liquid whilst the casting is undergoing the change from liquid to solid so as to maintain a ferro-static pressure.

Pouring Temperature

The temperature of pouring, the balance of carbon, phosphorus and silicon contents of the metal, and their influence on fluidity and shrinkage defects have been subjects of discussion for years, and there is little doubt that a high pouring temperature gives rise to a greater liquid shrinkage. At the same time it tends to equalise the cooling rate throughout the casting and assists the functioning of the feeder head. It has often been said, with considerable truth, that more waster castings have resulted from too low a pouring temperature, rather than the converse. Whilst it is obvious that limits must exist in either direction, it is almost certain that the average temperature of metal as supplied from cupolas is not likely to be too high when the pouring station is reached. In general terms, it is accepted that there are three stages in the solidification of cast iron:—(1) "Liquid shrinkage" of the liquid iron; (2) "solidification shrinkage," which occurs on the change from liquid to solid; and (3) "solid shrinkage," which occurs when the metal cools to room temperatures.

The thermal properties of the sand cavity are other factors, and it is possible to include exothermic or insulation materials in any part of mould face to increase local temperature or prevent heat radiation as a means to obtain the desired effect of preventing lateral or longitudinal solidification from those mould faces which interfere or prevent directional solidification towards the feeder. These facts are matters that are obvious in practice, and if one is somewhat hazy as to the meaning of certain terms, beloved of the metallurgist, and gets hopelessly involved in trying to understand some of the super carbon diagrams evolved for our benefit, one should still remember that the best proving ground is the foundry itself. From the practical angle, consistency of metal composition and temperature is of the first importance to promote conditions of stability if any general system of gating and feeder practice is to be proceeded with.

Standard Runners

Usually it is not practical to expect moulders correctly to proportion a runner system, as cut in the mould, to the constant accuracy required, and some help should be given them in this direction. It will be found of great practical use to develop some form of loose standard runner and give the necessary directives on the pattern card as to its positioning. The successful feeding of a casting depends initially on the recognition of the freezing range of the particular cast iron being used, and the ability to secure directional solidification by the positioning of the ingates, as no feeder, however well proportioned, will rectify mistakes in this direction. It is apparent of late that exponents of bottom running have given way to those who favour step, slit or top gating, because both of these latter methods are superior to bottom gating, as they do produce a heat flow suitable to static feeding. The well-known illustration from F. G. Sefings' Paper on this subject graphically illustrates heat flow and the temperature differentials obtained by bottom and top pouring of moulds.

Position of Ingates

It was usual, in most foundries, to gate castings in the thinner sections, to superheat the surrounding sand, in an attempt to equalise the temperature gradients throughout the mould, but as this method assumes an ability to evaluate the equivalent freezing point of differing masses of metal, at unequal distances from the ingates, it has been decided to contain the metal entry at the point where the greater mass of the casting occurs, even to the point of reducing metal distribution. This obvious way of producing favourable temperature gradients at the point of feed is at times undesirable, as the moulder often points out, but success in feeding depends on the adoption of this practice, or the near approach to it.

* Paper presented to the Birmingham branch of the Institute of British Foundrymen, with Dr. Angus, branch president, in the chair.

Running and Feeding of Castings

Step gating is a compromise of bottom and top gating, but it is not often realised that a control must necessarily be placed before the downgate which feeds the ingates, to ensure that the metal is built up in the downgate at the same level as in the mould. As a general rule, it may be said that feeders should be placed over the heaviest section of the casting, and that the feeder head should include the ingate. These feeders are usually known as "runner feeders," and, whether used as top or side feeders, they are more efficient than "off feeders." Since for reasons of economy it is desirable that the weight of the feeders be kept as low as is consistent with adequate feeding, considerable attention has been directed to feeder design.

Feeder Design

The work of Briggs has shown that the spherical feeder is easily the most effective, with the cylinder a bad second. In his work with steel, using a 6-in. dia. steel sphere, having a surface area of 113 sq. in., the casting solidified in 7.2 min., whereas a cylinder of 4¼-in. dia. by 8 in. long, having a surface area of 106 sq. in., solidified in 4.7 min. (both objects having an equal volume of 113 cub. in.), proving that the size of the feeder head may be determined by the "cooling factor." Janco has defined the "cooling factor" of feed head as "volume" divided by the "surface area in contact with mould."

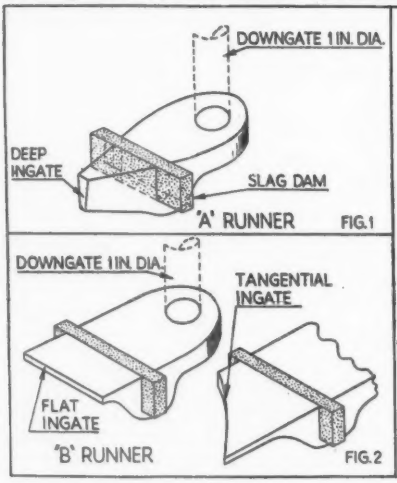
Jazwinski, Wells and Finch, using a cylindrical feeder, having a spherical head, proved that the least surface area to volume was an important factor in heat radiation from the head, and they also advised that the neck area from the feeder to the casting should be 40 per cent. of the cross-sectional area of the head at neck level. These investigators also made use of Williams' discovery, that of the utilisation of atmospheric pressure to a blind feeder head, which is of great value in reducing the volume of heads. Both Sefings and Jazwinski investigated the amount of liquid shrinkage in feeders and although their results did not agree, 10 to 12 per cent. of the casting weight, or of that proportion of the casting which has to be fed, is a good working guide for the weight of a feeder head.

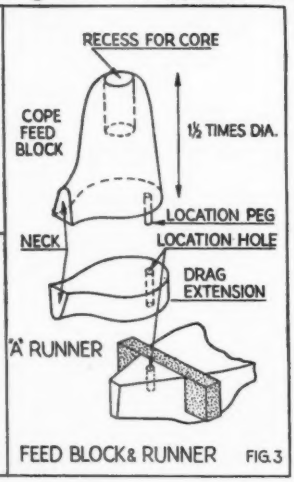
Chills

All these matters are "pointers" to good practice, and although the solidification mechanism of cast iron is different from that of steel, one should take full advantage of the theories which have been advanced to help steelfounders whose problems are more acute than ironfounders, but similar. Unfortunately castings vary so much in shape, and the ratio of surface area to volume, that one has at times to resort to the metal chill to balance up the temperature gradients in the mould. There is some element of risk in this method, owing to the fact that considerable turbulence can be caused in the mould by the molten metal "blowing" from a chill face. This occurrence, however, is rare, if the chill be clean, dry and adequately coated with a suitable type of chill dressing. It is also advisable to disperse a number of standard-size chills over the surface to be chilled, leaving sand gaps between, which vent the surface being chilled and provide an escape for any gases that may be generated. To place chills near to runners will render them useless, and will often result in chills being burnt on to a casting surface, but chills are very effective when the metal moves up to them, and the whole mould is rapidly poured.

Other Chill-inducing Media

At present the Author is making use of tellurium as a chilling agency on dried moulds or cores, where standard size cores cannot be used, or where there is a danger of a chill becoming locked. So far, he has been very successful in replacing the metal chills previously used, and has not experienced any trouble from "blows." Another aid is the use of

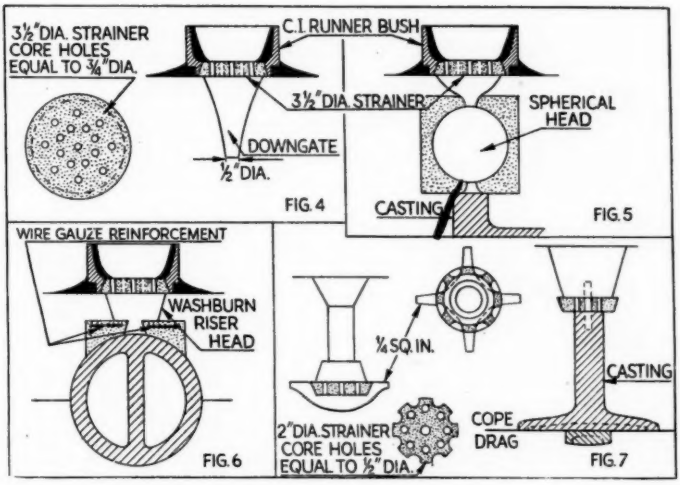




FIGS. 1, 2, AND 3.—*Trap Runners of Various Designs, made up as Standard Metal Patterns for Loose and Plated Jobs, all using a 1-in. dia. Downgate. Fig. 3 shows how the Blind Feeder Block is Located when Required.*

FIGS. 4 TO 7.—*Various Types and Uses of Strainer Cores.*

Fig. 4, Core Inserted in the Runner Bush on the Top of a Cope; Fig. 5, Strainer Core for Direct Running to a Feeder Head; Fig. 6, Runner System for Running Vertically on to the Casting, and Fig. 7, Core Inserted at the Mould Joint Line for Use without a Pouring Basin.



insulation material having a gypsum base around feeder heads, necks and risers. This often takes the form of a pre-manufactured sleeve, but it has been found difficult to exclude moisture pick-up in the sleeves from the air or mould, and unless the moisture content is controlled in the sleeve, the process is hazardous. In the United States, the insulating sleeve is protected from moisture pick-up, during storage, by a suitable plastic covering which is heat sealed and is competely effective.

Exothermic compounds on feeder heads open to the atmosphere have been effectively used in certain specific cases, but this aid needs hot metal at the feeder point if it is to function successfully. Gas feeding has possibilities, but the compound used by the Author was not sufficiently effective as to warrant its use in practice. It is hoped to give this matter further attention at some later date.

Standardisation

All these techniques are of great assistance, but the number of castings required often means that one cannot afford to make special runners and feeders, neither can one leave these matters to look after themselves, or as is often the case, to make a waster to arrive at the correct solution by trial and error. This returns to the original object of this Paper, which was to show that despite the variables and other matters associated with "jobbing work" one can create some standardisation and simplification of the methods employed and supply the craftsmen with a few tools that will incorporate modern practice in the running and feeding of castings. Figs. 1, 2, and 3 show trap runners which are made up as standard metal patterns for loose and plated work, for use with a common downgate of 1 in. dia. and all are for inclusion in the drag part of mould. The ingates have a cross-sectional area 0.25 sq in., this size having been determined experimentally as being the maximum area suitable for hand pouring. All other sizes are calculated back from the ingate and, in this case, areas are progressively increased from the ingate, ratios being ingate 1, area under trap $1\frac{1}{8}$ and downgate $1\frac{1}{8}$.

The dam in the slag trap illustrated was originally made as a core, but in practice, a metal casting has been substituted and, surprising as it may seem, a very few waster castings have resulted from this change. The blind feeder block Fig. 3, illustrates how this is positioned in relation to the runner when required; it will be noted that the area from the ingate to the blind feeder is controlled irrespective of the size of block used, so the feeder-block neck can be increased to any reasonable size without fear of slag inclusions. The feeder block is usually moulded in the cope for side feeding, as near the top of casting as is possible, but provision is made for the addition of an extension to position the feeder neck in the drag, when this is necessary. All feeder blocks should have spherical heads, and be recessed for the reception of a core to convert them to the atmospheric-pressure type when considered necessary. No runner bushes are necessary for this type of runner.

Strainer Cores

Figs. 4 to 7 show the use of strainer cores, where trap runners are not applicable. Fig. 4 illustrates the use of the strainer core on the top of cope, which is inserted in the runner bush. In floor moulding the downgate is formed by a special peg, and by a "jumping jack" (so called) in machine moulding. Fig. 5 shows the use of a strainer core for direct running through spherical or cylindrical feed heads, the spherical feed head being contained in the core as shown by the dotted portion. This particular system combines the use of the spherical head and the principle of the "Washburn core." Fig. 6 illustrates the runner system for vertical pouring directly on to a casting and Fig. 7 the inclusion of a strainer at the mould joint-line, for use without a pouring basin. It is a very efficient and

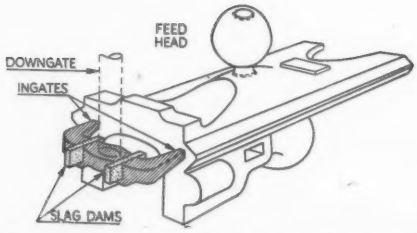


FIG. 8.—*Runner and Casting Assembly for a Press Slide, showing Incorporation of Two Dams in the Backgate and Two Ingates to the Casting.*

economical type of runner, where space is restricted in a mould but the ingate or gates into the casting must not exceed 0.173 sq. in. The holes in the strainer shown in Figs 4 and 5, total 0.442 sq. in. *i.e.* they are equal to a ¾ in. dia. downgate, whilst the holes of the strainer shown in Figs. 6 and 7 total 0.17 sq. in., *i.e.* they are equal to a ½ in. dia. downgate.

This type of slag trap is often misused, owing to the fact that the outlet of the downgate is of greater area than the holes in the strainer. This leads to a premature break-up of the strainer, but should the outlet of the downgate be restricted to ½ in and ⅜ in dia. respectively, the metal will swiftly build up in the downgate, and prevent the strainer from being overstressed. This restriction of outlet area will increase the effectiveness of the strainer as a slag " stopper." Either of the slag-trap runner systems can be connected to a backgate where it is necessary to have more than one ingate, as shown in the next illustrations. Fig. 8 shows the inclusion of two dams into the back-gate, having two ingates to the casting. In this case, the press slide is fed by the spherical head, owing to the fact that the cup of the slide, in the centre of the casting, is of a greater cross-sectional thickness than that of the side slides. Fig. 9 illustrates the " saw " or " spray-gate " using the strainer downgate. It will be noted that the backgates are moulded in the cope and the ingates in the drag. This method ensures that the thin gates necessary for the distribution of the metal in large-surface-area castings are adequately fed from backgates, so preventing the " sink " under the ingate, which often occurs when backgates are moulded in the drag.

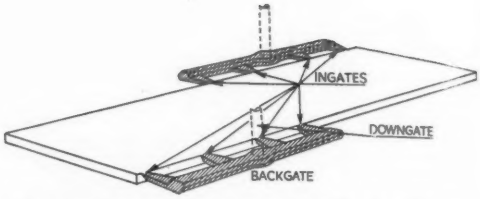


FIG. 9.—*Saw or Spray Gate using a Strainer Downgate. Backgates are Moulded in the Cope and Ingates in the Drag.*

Horizontal or Vertical Casting

Fig. 10 brings into focus the much-discussed problem of the use of the vertical or horizontal method of moulding bushes, sleeves, or other cylindrical castings. As previously stated, top-gating is preferable for positive feeding, but this runner was designed to incorporate the advantages of both top and bottom grating, and is known throughout the foundry as the " ring runner." It consists of a backgate, usually having a cross-sectional area twice that of the ingates, the bottom ingate being equal to the inlets into the backgate. Each side ingate is equal to half the area of the bottom ingate. The top gate is the feeder neck, which is made as large as possible, consistent with its easy severance by knocking off. In larger castings, a sump is often incorporated at the opposite end of the casting from that of the runner; it has been found effective in removing any trapped gases or dead metal at the top surface of castings. The control to the ring backgate is achieved by the " A " runner or runners. This runner method is now standard for all cylindrical castings, except those of thin section and relatively high axial length.

Fig. 11 shows a form of step gating used for printing rolls. It will be noted that the ingates are dispersed around the periphery of the roll to give a better distribution of metal than would have been possible if these had been gated in line from a horizontal downgate. This method prevents the formation of severe " hot spots " at one side of the mould. The control of the downgate is achieved by an enlarged " A " trap runner to the downgate and, as the trap bar melts, the speed of pouring progressively increases, preventing the formation of dead metal due to slow pouring. Only 1 in. of head metal is added to these rolls, but as this running system

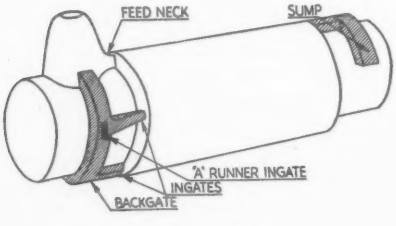


FIG. 10

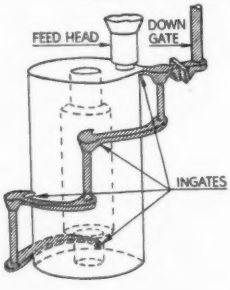


FIG. 11

FIG. 10.—*Running System for a Cylinder Moulded and Poured Horizontally, Incorporating Advantages both of Top and Bottom Gating.*

FIG. 11.—*Type of Step Gating applied to Printing Rolls which are Cast Vertically. The Method Permits Good Metal Distribution and Eliminates Hot Spots.*

creates favourable conditions for progressive solidification, the "Washburn" riser shown at the head is sufficient to feed the casting.

Other Systems

There are many other systems of runner gates which have been tried, but not standardised for various reasons. One is the pencil-gate runner as used for Diesel liners and often for flywheels, when dried moulds are used. This method relies upon the slow pouring of moulds using a high-temperature metal, but as fast pouring is preferred, this runner system has been discontinued. The "whirlgate" runner is also very effective if correctly proportioned, but is not so good for feeding heavy-section castings, and has restricted possibilities for standardisation.

Another form of runner, which has a certain popularity, is the "lip" feeder or "Connor runner," where the feeder block overlaps the casting by $\frac{1}{16}$ in. The downgate is gated to the feeder block, so that all metal entering the mould cavity passes through the narrow feed gate, and intensely heats the surrounding sand. The Author has had but little success with this method, and is of the opinion that the larger feed neck is preferable; also, that it is not possible to produce both a slag trap and feed neck in this manner. Yet another method of producing directional solidification, and one which is becoming increasingly popular, is the method of partial or full inversion of the mould, as practised in the States, particularly for Diesel liners. When standard methods of feeding cannot be applied, the Author uses steam feeding, and as a last resort rod feeding is practised, but both these methods should be applied to the feeder block, to prevent marking the casting.

Variables

To give any order of consideration to the variables that occur in the running and feeding of castings is not possible, as all associated factors are interdependent and, to provide a successful outcome, must all be considered together. It is, however, of the first importance that an endeavour should be made to keep one's practice in all things consistent, so that they may eventually be simplified and passed on to the craftsmen for use in their work, to make it increasingly standardised.

In closing, the Author would like to thank other authors referred to for their excellent Papers; also, the many unnamed research workers who, during the last ten years, have given so much time and thought to this problem which, in the writer's opinion, is one of the first essentials to be considered in good casting practice, that is, to decrease waste and increase yield. The Author's thanks are also due to his staff, who have done so much to help forward the idea that standardisation of runner methods, even in a jobbing shop, is practical. Last of all, he would like to express his appreciation of the interest which his co-directors in the firm of Rice & Company have taken in these activities.

DISCUSSION

MR. HARRISON asked what mixture Mr. Farmer used for applying tellurium.

MR. FARMER replied that the first mix tried was 25 per cent. tellurium, but this was not satisfactory. His firm were now trying 35 to 65 per cent.; they had also tried 50 per cent. on white irons to obtain a hard outer skin.

MR. TOMKIN elaborated on this question, and said that the chief trouble with tellurium, having made up the wash, was to keep it in suspension, because it settled fairly quickly and, once it had settled, it did so permanently. What they were endeavouring to do was to find some method of keeping it for a longer time in suspension. The Americans had tried several media, but so far they did not report that anything had been successful.

Tellurium Washes

MR. FARMER said that 20 per cent. tellurium was the maximum quantity required in any wash for a thickness of 6 in. and at the present time he was of the opinion that, if using bentonite, water and 20 per cent. tellurium, they would get what they required. Bentonite did not settle as quickly as most clays, and this he hoped would help matters.

DR. ANGUS asked whether with the 20 per cent. tellurium coating, say, on a boss, it was still machinable.

MR. FARMER said that the outside skin was certainly very hard, but was not as high as 300 Brinell.

MR. WILLIAMS asked whether Mr. Farmer could give the approximate weight of the tellurium mixture used on the surface, say roughly in gm. per sq. in.

MR. FARMER said that at present he and his colleagues were only experimenting, and it was only recently they had started, so there was no information at present. He would, however, be very pleased to let Mr. Williams know when they could give a definite answer.

MR. FRANCIS said that tellurium had been used quite a lot in this country, and as long ago as 1945 a Paper had been published in the FOUNDRY TRADE JOURNAL. He believed that it pointed out that there was no added advantage in adding more than 10 per cent. of tellurium powder. With tellurium, it was not so much that it was a chilling medium, but that the effect was more a chemical one and that in most cases a chilled skin about $\frac{1}{16}$ in. or $\frac{1}{8}$ in. deep was obtained. For overcoming porosity in bosses, he had found that all one had to do was just paint a strip with tellurium; it was not necessary completely to cover the surface area. Regarding runner/feeders, he had found that side runner/feeders were particularly effective on cast iron, similar to those shown in the illustrations, but there was one important point which had not been sufficiently emphasised, and that was that the base of the feeder should extend below the level of the connecter neck, so that there was no premature solidification of the neck. The feeder should extend part way into the drag, according to the weight of the casting. The notion was that the metal passing into the mould cavity preheated the surrounding sand. Anything which would help to establish this, in any kind of casting,

was a step in the right direction. Also, if the surface of the feeder could be kept open to atmospheric pressure, this was also a very great asset.

MR. FARMER said that he appreciated Mr. Francis's remarks, but they were finding very excellent applications for tellurium, especially in cases where they had previously been unsuccessful, and that he thought the best way was for everyone to experiment for themselves. With reference to the carrying of the feeder block below the joint line of the mould, they had found that it was unnecessary. They believed that by deepening their feeder neck, the neck kept open towards the top of the casting.

Phosphorus Content

MR. WRIGHT said he would like to issue a word of warning to Mr. Farmer about the use of tellurium, as the fumes were rather potent with sometimes rather embarrassing results. He would like to refer to low-phosphorus *versus* high-phosphorus castings. He maintained that with a 0.7 per cent. phosphorus iron it would be virtually impossible to make a cylinder head.

MR. FARMER thanked Mr. Wright for the warning and said that as regards cylinder heads, they had made them, but not in high-phosphorus iron. Their attitude was now that as there was going to be a difficulty in obtaining low-phosphorus irons, and the position might deteriorate due to circumstances over which they had no control, for that reason attempts were being made to utilise the high-phosphorus irons as an emergency measure.

MR. WRIGHT said he was very interested in Mr. Farmer's point, but it occurred to him that it would be better for the foundry industry as a whole to stress with the Ministry concerned that low-phosphorus irons were essential, rather than let the idea gain credence that only high-phosphorus irons need be used.

MR. HIRD said he presumed that the castings they had seen that evening were made in high-phosphorus iron. Could Mr. Farmer tell them the difference they made in the runner and feeder system.

MR. FARMER stated that the castings referred to were made in 0.8 per cent. phosphorus iron. The gating system was exactly the same, the only difference being in the feeder head. High-phosphorus irons melted at a lower temperature, and he felt that they remained fluid longer.

MR. WEAVER said he would like to know if Mr. Farmer would be prepared to say that the temperature did have an effect.

MR. FARMER said that he could certainly say this.

MR. HIRD then asked what Mr. Farmer termed as low-phosphorus iron.

MR. FARMER said anything below 0.4 per cent. they regarded as low-phosphorus iron.

Metal Slag Traps

A MEMBER asked about the metal piece inserted. Had Mr. Farmer tried any gating system using the slag trap without any insertion. Furthermore, Mr. Farmer had said that the metal tended to melt away slightly. Did that mean that the work of the slag trap was done in the first few minutes.

MR. FARMER said that they were very careful that the ingates were only 50 per cent. of the area of the downgates and that 50 per cent. of the saw-type runners were used with no slag trap. With the larger castings they assumed that the work of the trap occurred in the first few seconds of pouring. What they usually did was to see that the downgate was teemed very quickly so as to ensure a head of metal above. He said that they considered that a man pouring by hand could not keep up with an ingate which was more than $\frac{1}{4}$ sq. in. in cross-section. If a $\frac{1}{4}$ sq. in. with a 5 in. head was used, then it passed $2\frac{1}{2}$ lb. of metal per second through the ingate, that was assuming that the runner was directionally placed so that there was nothing to impede the passage of metal into the mould.

Pouring Temperature

A MEMBER suggested that in the case of ideal conditions for directional solidification, the lower the temperature for pouring, the better.

MR. FARMER replied that in fact they did not agree with this. They believed in pouring at as high a temperature as they possibly could. They increased the time of pouring rather than reduce the temperature of metal.

MR. WEAVER asked if Mr. Farmer could tell them what the percentage of scrap had been; what was the size of the cupola used, and how much metal was used at any one time.

MR. FARMER said the cupola was 30 in. dia. and run only in the afternoons. They cast 12 tons per day for five days per week. He thought quite definitely that their wastage was only 10 per cent. on the air-cylinder mentioned.

DR. ANGUS said that the discussion had been a very stimulating one. The question of tellurium intrigued him ever since he had heard of it, and though theoretically it did not work, practically it appeared to, and the proof of this had been put forward to the meeting by Mr. Farmer and his associates.

DR. KONDIC, in proposing the vote of thanks, said that the question of chilling by tellurium was most interesting, and also one of those most difficult to explain. He expressed on behalf of all those present the thanks and appreciation of everyone for a very interesting lecture.

MR. WRIGHT seconded the proposal, which was carried with enthusiasm.

Forty Years Ago

In the FOUNDRY TRADE JOURNAL for April, 1911, there is a most interesting Paper by the late Mr. John Shaw, giving a comparison between British and Continental foundry practice. Far too much complacency was exhibited during the discussion by individuals who should have been better informed—but then in 1911 one perhaps could afford to be complacent. In one article, of German origin, there were shown some really useful notions for drying both ladles and shanks. There is a long obituary notice of Lord Airedale, the great Yorkshire industrialist.

Supplies of Iron and Steel Scrap

Problems of Continuous Flow

During the past year the consumption of ferrous scrap in this country exceeded 14 milion tons, the bulk of which was used in iron and steel production. In view of the large increase in steel output, supplies of scrap are threatening to be inadequate and the British Iron and Steel Federation through their "Monthly Statistical Bulletin" appeal for an increased flow of scrap. The familiar sources are circulating scrap in the steel works and rolling mills; re-rollers' scrap, process scrap in industry and capital scrap, including that from the demolition of ships, buildings and bridges, the replacement of machinery and equipment and the discarding of old motor vehicles and containers.

Capital Scrap

A number of factors affect the supply of capital scrap. First is the input of manufactured products into the economic system in earlier periods and the distribution of the total between the different categories of goods—all having varying lengths of life. The steel that goes into a building may remain there for 50 years or more; but motor lorries may be scrapped after five or six years, while the life of a "tin" can is measured in months. The following figures relating to average useful life are taken from the latest report of the British Electricity Authority: Buildings (other than of an administrative nature) and civil engineering works (excl. hydro-electric works), 40 years; plant and machinery, 25; locomotives, barges and ships, 25; portable and testing instruments, 10; furniture, fittings and fixtures, 10; electrically-driven vehicles, 10; all yard wagons, 10; office machinery, 7; apparatus on hire (cookers, etc.), 7; petrol-driven vehicles, 5 years.

Anything which changes the pattern of steel consumption may thus be expected eventually to have its effect on the flow of capital scrap. It is probable that, on the average, the return of capital scrap to the steelworks is quicker in America than in this country, because of the much greater emphasis on motor cars and other vehicles. In general, it is probable that the growing relative importance of flat-rolled products in the United Kingdom will tend to speed up the turnover as the years pass. Another factor is the state of trade. Before the war the scrapping of machinery, vehicles and other capital equipment declined in periods of active trade. This was due mainly to the fact that it was worth while at such times to retain obsolete equipment in production, but partly also to shortage of labour needed to dismantle any plant not so required. In short, the effect of boom conditions was to lengthen the life of capital equipment. Naturally, however, the old plant and machinery so retained would be scrapped when the boom was over. The result was that the supply of capital scrap tended to follow a cyclical pattern, being least plentiful when it was needed most, thus greatly aggravating the fluctuations in the demand for steel-making pig-iron. If it is possible in the future to maintain reasonably stable employment, the scrapping of industrial plant and equipment, and therefore the flow of capital scrap, is likely to be much more even than in the past.

Since the war, arisings of capital scrap may have been reduced by the boom conditions prevailing, but the position has been complicated by a number of special factors. In 1946 substantial capital scrap supplies were coming forward as a result of the large-scale scrapping of war surpluses. In 1947 collections were hindered by bad weather and to some extent by the fuel crisis. There was a sharp recovery in 1948, mainly owing to the success of the industry's scrap drive, the effect of which continued into 1949 but had been exhausted by 1950. For most of the period, restrictions on the delivery lengthened the life of those already in existence and have made the car breakers very reluctant to part with worn-out vehicles. Last year's supply of capital scrap to the steel furnaces is estimated at 1,600,000 tons, bringing the total of home supplies of steel-making scrap to 8,160,000 tons.

Turnover Balance

One hundred tons of ingots and castings (together with 2 tons of imported ingots and semis) yield 74 tons of finished steel products and 25 tons of circulating scrap; the remaining 3 tons consist of mill scale and irrecoverable losses. Of the 74 tons of finished steel, 13 are exported—and therefore lost from the standpoint of scrap recovery—49 are delivered to home industry, 11 return as process scrap (including one to the blast furnaces) and one is lost. Finally, of the 49 tons delivered to consumers at home 12 are exported in manufactured form and 37 are retained for ultimate home use. For every 37 tons so retained last year, about 16 tons of capital scrap were returned to the steelworks and one to the blast furnaces. Total home scrap supplies thus amount to 53 tons for every 100 tons of ingots and castings produced. Of the 53 tons, 51 are delivered to the steel furnaces and two to the blast furnaces.

Regarding the prospect of a substantially larger return of scrap, so far as circulating and process scrap are concerned, no increase appears possible. But a return of only 0.7 ton of capital scrap for every 37 tons of steel retained for ultimate home use may seem inadequate; the question therefore arises whether the present flow of capital scrap is reasonably well related to the input of steel into the economic system over the past few decades. The first relevant point to note is the effect of the time lag in a period of rising consumption. Suppose, for the sake of argument, that the weighted

Supplies of Iron and Steel Scrap

average life of all steel products was 20 years and that steel consumption doubled every 20 years. Then the supply of capital scrap at any time could not be more than half the current rate of steel consumption. In fact it is not possible, with the information available, to work out a weighted average life—nor is this a fixed and invariable term of years. It is, however, true that home consumption of steel (about 14.7 million ingot tons in 1950) is more than twice the annual average for 1926-35 (7.1 million) and it is thus only to be expected that the tonnage of capital scrap arising should be well below the present level of steel consumption.

The position is, moreover, complicated by the fact that the useful life of a steel product may considerably exceed the life of the article in which it is incorporated. Second-hand structural steelwork may be incorporated into a new building; tubes and pipes may be used a second or third time, while sections of railway rails may enjoy a second, and very lengthly, spell of life as fencing posts. Again, many old rails are treated as billets, for re-rolling into such products as bedstead or fencing angles; discarded railway axles serve a similar purposes, while old tubes may be redrawn into new ones. On the basis of such information as is available, the supply of such second-hand and reusable material is estimated to be equivalent to half a million tons of ingots a year. Eventually, of course, much of this material will find its way back to the steelmakers as capital scrap, though the lapse of time may be very considerable.

But some part of the steel delivered to home industry is irrecoverable—*e.g.* that incorporated in ships lost at sea, in ammunition, etc., blown to pieces in course of war, and in articles which end their life in rubbish tips, perhaps in remote parts of the country. In addition, rust and corrosion take their regular toll. It is not possible to "qualify" these various factors, but they go far to explain the discrepancy between current home deliveries and arisings of capital scrap.

Principles of Flow Production

As a contribution to the solution of the problems of increased productivity, a series of six lecture-discussions for senior industrial executives will be held at the College of Technology, Birmingham, on the subject of "Basic Principles of Flow Production," on Saturday mornings commencing on April 21. The course will be conducted by Mr. F. G. Woollard, M.B.E., M.I.Mech.E., who has built up a store of practical experience in this subject during many years in the automobile and allied industries. He was a pioneer in the introduction of flow-production methods for the manufacture of automobile parts in this country, and as director and general manager of the engines branch of Morris Motors Limited he worked under Lord Nuffield to make the works a highly efficient production unit. Further particulars may be obtained from the Department of Industrial Administration, College of Technology, Birmingham.

Obituary

MR. HARRY CAMPBELL, late of Duncan Campbell (Ironfounders), Limited, Middleton (Lancs), died on March 22.

THE DEATH is announced of Mr. S. E. Cash, chairman of Stein & Atkinson Limited, for 24 yrs. He died after a short illness at the age of 72.

MR. T. N. VEITCH, joint managing director of Hague & McKenzie, Limited, aluminium hollow-ware manufacturers, of Birmingham, died recently.

MR. J. J. BARRIE, of Dundee, who has died at the age of 67 in a London nursing home, was chairman of James F. Low & Company, Monifieth Foundry, and held several other business appointments in the district.

MR. ALFRED LESLIE BALLAM, a director and secretary of the Parsons Engineering Company, Limited, Southampton, who died recently, joined the company over 45 years ago shortly after its formation. He was 69.

MR. E. W. SWALLOW, who retired from the post of assistant chief docks manager, South Wales ports, for the Docks and Inland Waterways Executive, at the end of last year, died in hospital near Cardiff on March 24, after a three-week illness.

MR. JOSEPH ALFRED ORCHARD, sales manager of Universal Grinding Wheel Company, Limited, Stafford, died on March 21 at the age of 52. He joined the company in 1922. For some years Mr. Orchard had been secretary of the Abrasive Industries Association.

MR. T. B. MCNAIR, a member of the board of management of John Brown & Company, Limited, shipbuilders, etc., of Clydebank, died on March 19 at the age of 66. He entered the counting house of the company more than 50 years ago, and in 1934 became commercial manager.

MR. HARRY PAGETT, who retired a year ago from the post of chief designer and head of the compressor drawing office of Belliss & Morcom, Limited, manufacturing engineers, of Birmingham, has died at the age of 65. He spent the whole of his working life in the employ of the company and was associated with the design and development of its air compressor from the outset.

MR. ERNEST WALTER RAINER, who died on March 21, was managing director of Howard W. Meredith & Son, Limited, builders' hardware merchants, of London, S.E.1, and also joint managing director of Rownson, Drew & Clydesdale, Limited, manufacturers of elevators and conveyors, etc., of London, E.C.4. Mr. Rainer was well known in industrial circles for his work as a vice-president of the National Union of Manufacturers.

DR. CYRIL BATHO, Beale Professor of Civil Engineering in the University of Birmingham, until his retirement from the Chair at the end of 1949, died on March 23 at the age of 65. He was recently given the title of Professor Emeritus. Dr. Batho returned to this country in 1924 after a period of notable achievement in Canada. He was appointed Assistant Professor in Civil Engineering at McGill University in 1911, and after the 1914-18 war, during which he was a research officer of the Canadian Machine-Gun Corps, returned there to take up the post of Associate Professor of Applied Mechanics and Hydraulics. He was assistant designing engineer for the New Quebec Bridge in 1912-13. From 1929 to 1936 Dr. Batho was a member of the Steel Structure Research Committee. He published many papers on elasticity, structural engineering, and thermodynamics.

Improving Machinability of Ductile Iron by Annealing*

By J. W. Kahles and R. Goldhoff.

Adequate machinability and physical properties can be obtained in ductile iron without complete pearlite decomposition. Increased silicon content accelerates carbon solution, while pearlite breakdown is mainly a function of the manganese content. Small amounts of carbide can be tolerated if the matrix is basically ferrite.

THE ANNEALING characteristics of ductile irons are important in a commercial sense both to the manufacturer and user of ductile-iron castings. For many years, much emphasis has been placed upon high strength in cast irons. This approach has often led to the application of high-strength irons where a lower-strength iron with markedly improved machinability would be much more economical.

To correlate the influence of annealing on the physical properties and machinability, two basic types of ductile irons were considered:

(1) The carbidic irons, which are ductile irons of the usual composition. When this material is cast in thin sections such as found in thin plates and pipe fittings, the microstructure shows appreciable quantities of free iron carbide; and (2) the normal ductile irons having spheroidal carbon in a matrix of pearlite and ferrite. In the as-cast structures, the percentage of pearlite is greater than that of ferrite. Consequently, they are often referred to as pearlitic, in contrast with the carbidic irons.

The procedures used were dictated to some extent by current practices in ductile-iron annealing. Briefly, most cycles now used involve a temperature of 900 or 925 deg. C. for about ½ hr. followed by cooling to 690 deg. C. and holding for about 5 hr.

Variation in Solution Times

All of the carbidic-iron specimens showed similar carbide decomposition characteristics. Carbide decomposition implies solution of the iron carbide in austenite and any attending graphitisation. Fig. 1 shows the typical rate of carbide decomposition at temperatures of 870, 938 and 980 deg. C. Virtually complete decomposition takes less than 1 hr., particularly at the higher temperatures. Complete carbide solution was reported[1] to vary from 1½ to 7 hrs., depending on the temperature and the chemical composition of the iron in question. Table II shows the effect of silicon content on the rate of carbide decomposition.

TABLE I.—*Chemical Compositions of Samples Used.*

	T.C.	Si.	Mn.	P.	S.	Ni.	Mg.
(1) Carbidic iron—							
1A	3.59	3.12	0.52	0.130	0.017	0.78	0.082
1B	3.34	3.27	0.45	0.084	0.02	0.70	0.066
1C	3.39	3.28	0.45	0.084	0.02	0.70	0.066
1D	3.31	3.75	0.45	0.084	0.02	0.70	0.066
1E	3.35	3.96	0.45	0.084	0.02	0.70	0.066
(2) Carbidic Iron, 2	3.42	2.98	0.61	0·06	0.019	1.37	0.060
(3) Pearlite-ferrite (ductile iron)	3.42	2.98	0.61	0.06	0.019	1.37	0.060
(4) Pearlite-ferrite (ductile iron 3 in. round)	3.58	2.33	0.40	0.052	0.010	1.35	0.076
(5) Pearlite-ferrite (ductile iron 6 in. square)	3.52	2.46	0.43	0.096	0.009	1.91	0.085

The chemical compositions of materials used in this investigation are shown in Table I. Specimens 1A, 1B, 1C, 1D, and 1E are carbidic irons having the same base analyses. A variation in ferro-silicon inoculation was used to provide data on the effect of varying silicon content. Specimens from No. 2 were taken from the thin section in a step bar.

Pearlitic specimens were obtained from three sources: No. 3 from the 1-in. section of a step bar; No. 4 from 30-in. lengths of 3-in. rounds; and No. 5 from a 6-in. square section. Originally, all of the above materials were in the as-cast condition. With heavy sections and long lengths, there are variations in the percentages of structures.

Variables besides the silicon content are present. The iron compositions involved are fairly comparable, however, and the data are considered representative of at least a trend in the effect of silicon content on subsequent carbide decomposition. The resulting lower times of solution with increased silicon content follow typical white-iron decomposition characteristics. Other compositional effects can probably be inferred from typical malleable and white-iron behaviour.

Appreciable amounts of carbide (even as low as 3 per cent.) in the microstructure are known to drastically decrease tool life in pearlitic grey irons. This occurs because such structure is imbedded in a relatively hard pearlitic matrix. In steel, the spheroidisation basically provides a soft ferritic matrix for the carbide, increasing machinability. It follows that residual amounts of carbide might be tolerated in ductile irons with a basically ferritic

* Abstract of an article printed in the *Iron Age* under the caption of "Anneal Ductile Iron for Better Machinability." The Authors are Associate Professor of Metallurgy and Graduate Student, University of Cincinnati.

Improving Machinability of Ductile Iron

TABLE II.—*Silicon* v. *Carbide Decomposition.*

Silicon, per cent.	Time for 95 per cent. Fe_3C decomposition.	
	925 deg. C. (min.).	980 deg. C. (min.).
2.98	38	—
3.12	40	32
3.27	32	32
3.28	32	32
3.75	16	13
3.96	20	17

TABLE III.—*Analysis* v. *Pearlite Decomposition.*

Ductile irons.	Composition, per cent.				Time to reach 15 per cent. Pearlite, hrs.
	C.	Si.	Eff. Mn.	P.	
(3) Pearlite-ferrite, step bar ..	3.42	2·98	0.55	0.06	5
(4) Pearlite-ferrite, 3 in. round ..	3.52	2·46	0.40	0.052	4
(5) Pearlite-ferrite, 6 in. square ..	3.58	2.33	0.37	0.096	2.5

matrix. The difference in cost between annealing times for complete carbide solution and decreased tool life from residual carbide might favour the latter.

Pearlite may be decomposed in one of two ways. First, specimens may be cooled from above the critical slowly through the critical temperature range, then held at a constant sub-critical temperature for a definite length of time. Fig. 2 shows the rate of pearlite decomposition where the specimen has ben held at 954 deg. C. for ½ hr., furnace cooled to 690 deg. C. and held. An alternate procedure involves simply eliminating the austenitising treatment and only heating to subcritical temperatures. Fig. 3 shows this decomposition for the same composition used in Fig. 2.

In both cases, a rather rapid rate of pearlite decomposition was followed by much longer indicated times for the elimination of small amounts. All of the pearlitic irons noted in Table I showed comparable decomposition trends. Microstructures seemed equivalent except for the form of pearlite involved. The specimens decomposed by sub-critical temperature treatment show more pearlite spheroidisation when examined at magnifications of the order of × 1000. This leads one to question the necessity of solution heat-treatment in the austenite field, where small amounts of carbide cannot be decomposed anyway. The answer might lie in the determination of physical properties obtained for each type of treatment.

Effective Manganese

Compositional effects have already been estimated by Rehder.[1] [2] Information obtained here substantiates his findings, even though the data are not extensive. Apparently the Mn : S ratios or effective manganese contents in ductile irons are determining factors in rates of pearlite decomposition. Reference is made to Table III. Virtually all of the manganese is effective as an alloying element because ductile iron is practically sulphur-free. The implications of this fact are far-reaching because of the enormous savings of manganese that may be achieved—a very vital factor in metal economy.

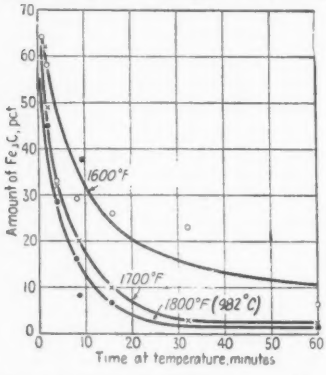


FIG. 1.—*Typical Curves for the Decomposition of Iron Carbide in a Carbidic Iron at various Temperatures. Composition of the Iron was TC.* 3.34, *Si* 3.27, *Mn* 0.45, *P* 0.084, *S* 0.02, *Ni* 0.70 *and Mg* 0.066 *per cent.*

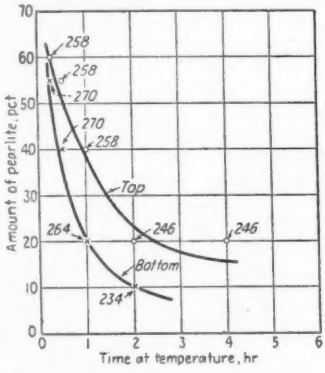


FIG. 2.—*Graph showing Decomposition of Pearlite in the Pearlitic type of Ductile Iron, Austenitised at* 1,750 *deg. F.* (954 *deg. C.*) *for* 30 *min. and Decomposed on Continuous Cooling to and Holding at* 1,275 *deg. F.* (690 *deg. C.*). *Composition:—T.C.* 3.58, *Si* 2.33, *Mn* 0.40, *P* 0.052, *S* 0.01, *Ni* 1.55, *and Mg* 0.076 *per cent. Brinell Hardness Readings were taken at the Points Shown.*

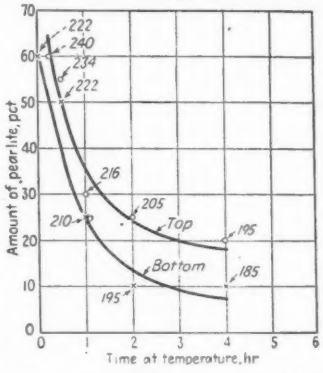


FIG. 3.—*Pearlitic Decomposition in a Pearlitic Ductile Iron held at a Sub-critical Temperature of* 1,275 *deg. F.* (690 *deg. C.*). *Metal Composition is the Same as in Fig.* 2; *Brinell Hardnesses as Shown.*

As with other grey irons, there was a persistence of pearlite in areas where steadite was present. The amount of steadite present for these irons was small, as one might expect from the low phosphorus content of these irons.

TABLE IV.—*Average Physical Properties.*

Amount of Pearlite, per cent.	Tensile strength, tons per sq. in.	Yield strength, tons per sq. in.	Elong., per cent.	R.A., per cent.	Hardness, B.H.N.
65	46.0	—	6.5	3.5	230
50	35.7	26·8	16.0	12.0	200
20	33.5	24·5	19.0	15.5	180
3	34.4	27·7	20.0	22.0	180

Machining data were not taken on all of the irons, but were directed primarily to the machining of material to analysis No. 4. This ductile iron was vertically cast in 30-in. lengths, 3-in. rounds, which were convenient for the evaluation of machinability. Twenty-three bars were cast. Some

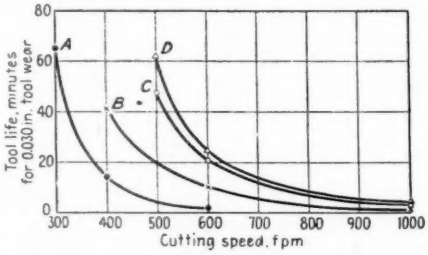


FIG. 4.—*Curves showing the Effect of Microstructure on Tool Life at varying Cutting Speeds, with Tool Life Plotted against Cutting Speed. Sample A is As-cast, B is the 50 per cent. Pearlite Structure, C has 20 per cent. Pearlite, and D 3 per cent. Physical Properties are listed in Table IV and the Composition is No. 4 in Table I.*

of them were subsequently annealed at 900 deg. C., followed by a 690 deg. C. treatment to give various combinations of pearlite and ferrite. Table IV lists physical properties for the No. 4 analysis, obtained from keel blocks accompanying the casting and annealing practice.

Turning tests were made on an infinitely variable-speed lathe under the following conditions: Feed, 0.011 in. per rev., depth of cut, 0.100 in., with a carbide-tipped tool. No back rake was set on the tool, and side rake was at a 6 deg. angle; the end cutting edge angle was 6 deg., as were the side and end relief angles; there was no side cutting edge angle.

The relation between tool life and cutting speed for the various annealed structures is shown in Figs. 4 and 5. In Fig. 4, the tool life in minutes required to produce 0.030 in. wear land on the flank of the carbide is plotted against cutting speed. In Fig. 6, the same data are re-plotted with tool life given in terms of cubic inches of metal removed instead of time.

Considerable improvement in tool life was obtained by annealing so as to transform the structure from 65 to 20 per cent. pearlite. Only a small further improvement in tool life was obtained by continuing the annealing to provide 3 per cent. pearlite, as shown in Table V. It thus appears that the economical structure for machining in this

TABLE V.—*Pearlite* v. *Tool Life.*

Structure, per cent. Pearlite.	Anneal time at 1,275 deg. F., hr.	B.H.N.	Relative cutting speed, ft. per min. for	
			40 min. tool life.	200 cu. in. tool life.
65 (as cast)	—	230	325	320
50	0.75	200	405	420
30	1.5	180	520	565
3	5.0	180	550	600

particular case would be the 20 per cent. pearlite, which was held at 690 deg. for only 1½ hr.

Table IV shows fairly conclusively that relatively high ductility is obtained before pearlite is completely removed. This work, along with other

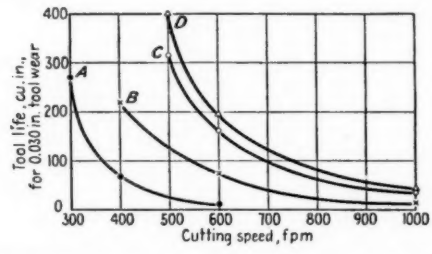


FIG. 5.—*The Same Data as presented in Fig. 4, replotted with Tool Life in terms of Cub. In. of Metal Removed instead of Time.*

experience, indicates that in ductile irons one can rely to a great extent upon microstructure in predicting machinability. This correlation has been shown in other cast irons by Field and Stansbury.[3]

REFERENCES

1 J. E. Rehder, "An Introduction to the Annealing of Nodular Iron," *A.F.S. Reprint* No. 50-17, 1950.
2 J. E. Rehder, "Effect of Mn: S Ratio on the Rate of Anneal of Blackheart Malleable," *A.F.S. Trans.*, vol. 58, 1949, p. 138.
3 M. Field and E. Stansbury, "Effect of Microstructure on Machinability of Cast Irons," *A.S.M.E. Trans.*, August, 1947, p. 665.
4 U.S. Air Force Machinability Report, Curtiss-Wright Corp., 1950.

Engineering, Marine and Welding Exhibition

This exhibition, which is to be held at Olympia from August 30 to September 13, will carry a Foundry Trade Exhibition—that is, in reality, a foundry equipment and supplies section. The official bulletin, which is available to our readers on writing to the organisers at Grand Buildings, Trafalgar Square, London, W.C.2, states that 27 firms are showing in the foundry section. This does not mean to say that there are only this number of firms whose products are of interest to the foundry industry, for there are many more distributed throughout the engineering section.

Book Review

The Structure and Mechanical Properties of Metals by Bruce Chalmers. Published by Chapman & Hall Ltd., 37, Essex Street, London, W.C.2. Price 18s.

Recognising, no doubt, that in aircraft metals are exposed to more searching conditions than in any other form of construction so that the aeronautical engineer must live in close harmony with the metallurgist, the Royal Aeronautical Society has sponsored a series of Monographs on Metallic Materials. Most of these will deal with subjects of direct interes' to the engineer, such as the properties of materials at low temperatures, and the present volume is exceptional in having a more theoretical basis. The relation between the mechanical properties of metals and their nature as particularly revealed by X-rays has made great progress in the past few decades, and metallic deformation has been studied in relation to crystal structure considered first as a perfect lattice and, later as possessing the defects now known as "dislocations." In the present volume Prof. Chalmers summarises the modern structural theories and relates them to the technical properties of metals and alloys. Four chapters are devoted to the structure of pure metals and alloys and to the effects of distortion and heat-treatment, followed by a very short account of the principal methods for determining structure; the book ends with an extended chapter on the dependence of mechanical properties on structure. Metallurgists will find much that is familiar in this book. Thus there are clear accounts of the various types of binary alloy systems, according to whether the component metals are miscible in the molten state and soluble in each other after solidification, and solid-state transformations are exemplified by age-hardening and eutectoid alloys. Nevertheless, the reviewer must express a certain feeling of disappointment with Prof. Chalmers' treatment of what he considers to be the central themes of the book—first, the relation between structure and the various mechanical properties and, secondly, the inner significance of the technical properties. The author explains in his preface that "in avoiding any resort to mathematical considerations" he "has necessarily glossed over many of the finer points and has had to be content with a rather superficial approach to some aspects of the subject." It may be that this deliberate policy is responsible for the unsatisfied feeling experienced after reading certain sections. Thus when dealing with indentation hardness the author states that the "result depends on a complex combination of the elastic constants, the elastic limit and the shape of the stress-strain curve. The hardness cannot be calculated from the stress-strain curve, but for a given type of alloy (such as steel) it is generally found that the hardness is proportional to the ultimate tensile strength. This is because the shape of the stress-strain curve varies in a regular manner as the strength increases, and so the hardness will also vary linearly." In passages like this the author raises the reader's expectation by suggesting that he is about to make an enlightening synthesis; unfortunately, the ideas often run away like blobs of mercury without ever being convincingly united.

The impression left by this book on the reviewer's mind is uneven and confused. There remains a real need for a short exposition relating the modern theories of the imperfect lattice to the technical properties of metals and alloys. D.C.G.L.

THE BOARD OF TRADE have made an Order coming into effect on April 9, permitting increases on the maximum prices of sulphuric acid, due mainly to the advances in the world prices of sulphur and pyrites and of freight rates.

New Catalogues

Pelleted Pitch. A really useful pamphlet has just been issued by the Midland Tar Distillers. Limited, of Oldbury, Worcestershire. The presentation is unostentatious but quite pleasing. The contents have been well chosen and clearly set out. First there is an excellent description of the general properties of pelleted pitch as a material to replace coal dust or as a bonding agent. A photomicrograph—the word is unfortunately transposed in the text—shows the spherical formation of the material, but again unfortunately the magnification has been omitted. After setting out nine quite reasonable claims, a list of foundries using pelleted pitch is given. Finally and wisely, the "recommended (B.C.I.R.A.) procedure for the determination of extractable matter in moulding-sand/pitch mixtures" has been included. As the subject-matter is of topical interest, it is suggested that readers write to Oldbury for a copy.

Scrap Means Steel. T. W. Ward, Limited, Albion Works, Sheffield, have done good service to industry by preparing and issuing to those not too well-informed as to the importance of scrap in the economic welfare of this country, a well-documented pamphlet. The illustrations and the letterpress have been well chosen to impress upon the reader the transformations which scrap metal undergoes. The repetitive design on the covers of "scrap-steel-scrap-steel" is subtly appropriate.

Flaw Detection. A four-page leaflet received from Fel Electric, Limited, of 41, Sidney Street, Sheffield, 1, describes recent developments in the conventional oil-and-chalk method for detecting cracks and imperfections in non-ferrous castings. Both the "oil" and the "chalk" have been the subject of investigation and a new material carrying the trade name of "Nonfertec" has been placed on the market. It gives brilliant red stains or lines.

Furnaces. We have received from Dowson & Mason Gas Plant Company, Limited, Levenshulme, Manchester, 19, their Bulletin No. 4. This is a four-page leaflet, the cover of which shows a battery of mould-drying stoves installed in the foundry of Wm. Beardmore & Company, Limited, Glasgow. The next two pages include pictures of gas-fired heat-treatment furnaces for castings.

House Organs

The Buckle. Published for private circulation by C. P. S. Sanderson, Limited, 107, Jermyn Street, London, S.W.1.

The publishers have asked for an opinion of the first two issues. The first thing to note is that the booklet is printed as a service to customers. They are given some technical data and some quite well-written humorous articles. The internal social affairs should therefore be reported in brief—just sufficient to let the customer know that such things happen. "The Buckle" is neatly cyclostyled and is quite a presentable publication. The telephone number might be usefully incorporated.

Foundry Practice, No. 102. Issued by Foundry Services, Limited, Long Acre, Nechells, Birmingham, 7.

There is in this issue an article covering a cylinder casting riddled with blowholes and of the wrong composition. A second one deals with moulding-box bars, whilst one on crucible furnaces for melting iron completes the contents.

Lithium in Vitreous Enamels*

By S. Hallsworth

The purpose of this study was to determine the effect of lithium additions to various types of vitreous enamels. It was decided to limit the investigations to the actual effect such as would be experienced in production rather than carry out academic research into the scientific explanation of the results obtained by the inclusion of lithium.

IN THE EXPERIMENTS, with the exception of sheet-iron ground coats, where lithium manganite was substituted for manganese dioxide, the investigation was restricted to the use of lithium as an additional fluxing agent, instead of a substitute for alkalis and other fluxes. By reason of its availability, lithium carbonate was selected for the experiments on smelter additions (with the exception referred to previously).

It will be appreciated that with the wide difference in the types of frit studied, certain variations had to be made both in procedure and testing, but these were kept constant between the non-lithium and lithium-bearing enamels in each series, thus showing the direct effect of the addition. Although there is considerably more information published on sheet-iron ground coats and titanium cover coats than was embraced in the summary of available literature included as an Appendix, it was decided to include them in the general survey.

Procedure

The characteristics of the enamels used were studied in accordance with the various requirements of the particular frits.

Smelting and Application

Raw batches of approximately 4,000 gm. were used and smelted in gas-fired crucible furnaces. Smelting temperatures were varied to suit the individual frits and a number of prior trials were made in each case to determine the best temperature. The enamels were milled in porcelain jar mills using 2,800-gm. charges. Milling was controlled to give the minimum variation in particle size in each series of frits. Fusing was carried out in an electric furnace 36 in. by 24 in. by 12 in., the furnace being suitably loaded to give comparable temperatures with those obtained on production muffles. The fusing temperature indicated in the Tables is that which gave the best results on visual examination.

Methods of Testing

The button-fusion test† was used to determine the fluidity, the buttons being kept at a uniform size of 1.7-cm. dia. and weight of 3.5 gm. when dry. Ground-coated plates 8 in. by 8in. by 18 in. bent at an angle of 90 deg. were used throughout the trials. With the sheet-iron enamels, the buttons were fired in an upright position for 3 min. at 820 deg. C. The plates were then rotated through 90 deg. and the buttons fired for a further 5 min. The cast-iron enamels were given the same treatment, but the temperature was reduced to 780 deg. C. The maximum length and width of flow were measured and the product of these is given in sq. cm.

Reflectance was measured by means of the Albright Reflection Meter and values are given with the amber, green and blue filters, no correction being made after standardising the instrument. Gloss was also measured on the Albright meter as well as a visual appreciation.

The calculated coefficient of expansion was obtained using Mayer and Havas tables, with a factor of 10 for lithium oxide. The actual expansion was measured on a modified Gale dilatometer using uniform test-pieces. Acid resistance was determined in accordance with B.S.I. methods of testing vitreous-enamel finishes.

Nomenclature

The frits were identified with the following numbers:—

(1) Normal ground-coat enamels;

TABLE I.—*Raw Batch Weights, Composition and Characteristics of Sheet-iron Ground-coat Enamels.*

	Enamel No.			
	1.	2.	3.	4.
Raw Batch (gm.).				
Dehydrated borax	932	932	932	932
Felspar	1,444	1,444	1,444	1,444
Quartz	676	676	676	676
Fluorspar	424	424	424	424
Soda ash	236	236	236	236
Saltpetre	192	192	192	192
Manganese dioxide	48	—	48	48
Cobalt oxide	28	28	28	28
Nickel oxide	20	20	20	20
Lithium manganite	—	48	—	—
Lithium carbonate	—.	—	32	60
Calculated Melted Composition (per cent.).				
SiO_2	43.06	43.06	42.86	42.82
Al_2O_3	6.79	6.79	6.77	6.75
B_2O_3	16.85	16.85	18.81	16.67
Na_2O	12.06	12.06	12.04	11.98
K_2O	6.65	6.65	6.63	6.63
CaO	7.18	7.18	7.16	7.15
CoO	0.75	0.75	0.75	0.75
NiO	0.53	0.53	0.53	0.53
MnO_2	1.28	0.95	1.28	1.28
F_2	4.85	4.85	4.84	4.83
Li_2O	—	0.33	0.33	0.61
Characteristics.				
Fluidity (flow) (sq. cm.)	11.13	12.65	12.76	13.34
Calculated coefficient of expansion (in. × 10-7)	291	293	294	296
Actual coefficient of expansion (in. × 10-7)	293	297	298	301
Fusing temperature (deg. C.)	850	835	835	825
Under-fired temperature (deg. C.)	830	815	815	805

* Paper presented at the 16th Annual Conference of the Institute of Vitreous Enamellers, Harrogate, November, 1950.

† *Jnl. Amer. Ceram Soc.*, 1949, **32** (3), pp. 114-20.

Lithium in Vitreous Enamels

TABLE II.—*Raw Batch Weights, Composition and Characteristics of S.I. Antimony-containing Cover-coat Enamels.*

	Enamel No.	
	5.	6.
Raw Batch (gm.).		
Dehydrated borax	566	566
Felspar	898	988
Quartz	972	972
Soda ash	223	223
Saltpetre	135	135
Zinc oxide	102	102
Cryolite	395	395
Fluorspar	138	138
Barium carbonate	42	42
Sodium antimoniate	529	529
Lithium carbonate	—	60
Calculated Melted Composition (per cent.).		
SiO_2	41.89	41.60
Al_2O_3	5·57	5.54
B_2O_3	10.29	10.22
Na_2O	14.21	14.12
K_2O	4.39	4.37
ZnO	2.71	2.71
CaO	2.36	2.36
BaO	0.87	0.87
Sb_2O_5	10.62	10.52
F_2	7.09	7.07
Li_2O	—	0.62
Characteristics.		
Fluidity (flow) (sq. cm.)	11.34	12.90
Calculated coefficient of expansion (in. × 10-7)	299	303
Actual coefficient of expansion (in. × 10-7)	303	307
Fusing temperature (deg. C.)	835	825
Under-fired temperature (deg. C.)	820	810
Reflection, tri-amber filter	78	79
,, tri-green filter	78	80
,, tri-blue filter	77	79
Gloss	89	96

(2) As (1) with the manganese dioxide replaced with lithium manganite;

(3) The same lithium-oxide content as No. 2;

(4) As (1) with the addition of 1.5 per cent. lithium carbonate;

(5) Normal sheet-iron antimony-opacified cover-coat white;

(6) As (5) with the addition of 1.5 per cent. lithium carbonate;

(7) Normal sheet-iron acid-resisting antimony-opacified white;

(8) As (7) with the addition of 1.5 per cent. lithium carbonate;

(9) Normal sheet-iron titanium white;

(10) As (9) with the addition of 1.5 per cent. lithium carbonate;

(11) Normal wet-process cast-iron white;

(12) As (11) with the addition of 1.5 per cent. lithium carbonate;

(13) Normal acid-resisting wet-process cast-iron white;

(14) As (13) with the addition of 1.5 per cent. lithium carbonate.

Discussion of Results

The composition and characteristics of the various enamels are given in Tables I to VII.

Sheet-iron Ground-coat Enamels

It was found to be difficult to assess the correct fusing temperature of the lithium-containing ground-coat enamels, as satisfactory fusion was obtained at 825 to 850 deg. C. Very little difference could be

TABLE III.—*Raw Batch Weights, Composition and Characteristics of S.I. Acid-resisting Antimony-containing Cover-coat Enamel.*

	Enamel No.	
	7.	8.
Raw Batch (gm.).		
Dehydrated borax	473	473
Felspar	256	256
Quartz	1,559	1,559
Soda ash	756	756
Saltpetre	184	184
Titanium	260	260
Sodium silico fluoride	160	160
Calcium phosphate	60	60
Antimony oxide	292	292
Lithium carbonate	—	60
Calculated Melted Composition (per cent.).		
SiO_2	49.10	48.83
Al_2O_3	1·28	1.27
B_2O_3	9.04	8.99
Na_2O	17.93	17.75
K_2O	3.20	3.17
CaO	0.92	0.92
Sb_2O_5	8.07	8.02
TiO_2	7.20	7.15
F_2	2.67	2.67
P_2O_5	0.59	0.59
Li_2O	—	0.64
Characteristics.		
Fluidity (flow) (sq. cm.)	9.24	10.35
Calculated coefficient of expansion (in. × 10-7)	317	323
Actual coefficient of expansion (in. × 10-7)	294	297
Fusing temperature (deg. C.)	830	820
Under-fired temperature (deg. C.)	810	805
Reflection, tri-amber filter	72	74
,, tri-green filter	73	76
,, tri-blue filter	73	75
Gloss	95	96
Acid resistance	Slight stain at 830 deg. C. Fusing, no stain when fused at 840 deg. C.	Slight stain at 815 deg. C. Fusing, no stain when fused at 825 deg. C.

TABLE IV.—*Raw Batch Weights, Composition and Characteristics of S.I. Titanium-containing Cover-coat Enamel.*

	Enamel No.	
	9.	10.
Raw Batch (gm.).		
Dehydrated borax	662	662
Quartz	1,913	1,913
Saltpetre	368	368
Soda ash	136	136
Zinc oxide	149	149
Sodium silico fluoride	161	161
Titanium oxide	611	611
Lithium carbonate	—	60
Calculated Melted Composition (per cent.).		
SiO_2	51.84	51.55
B_2O_3	12.07	12.02
Na_2O	9.96	8.85
K_2O	4.50	4.47
ZnO	3.93	3.91
TiO_2	16.13	16.04
F_2	2.57	2.55
Li_2O	—	0.61
Characteristics.		
Fluidity (flow) (sq. cm.)	5.72	7.43
Calculated coefficient of expansion (in. × 10-7)	245	249
Actual coefficient of expansion (in. × 10-7)	253	259
Fusing temperature (deg. C.)	840	825
Under-fired temperature (deg. C.)	825	805
Reflection	See Table VII	
Acid resistance	Satisfactory at 840 deg. C.	Satisfactory at 825 deg. C.
Gloss	87	97

TABLE V.—*Raw Batch Weights, Composition and Characteristics of Wet-process Cast-iron White Enamel.*

	Enamel No. 11.	Enamel No. 12.
Raw Batch (gm.).		
Dehydrated borax	919	919
Felspar	829	829
Quartz	673	673
Saltpetre	194	194
Barium carbonate	293	293
Cryolite	134	134
Zinc oxide	573	573
Fluorspar	229	229
Antimony oxide	156	156
Lithium carbonate	—	60
Calculated Melted Composition (per cent.).		
SiO_2	32.10	31.93
Al_2O_3	4.31	4.28
B_2O_3	16.52	16.43
Na_2O	9.03	8.98
K_2O	4.82	4.79
ZnO	14.91	14.83
CaO	3.86	3.83
BaO	5.95	5.89
Sb_2O_5	4.06	4.03
F_2	4.44	4.41
Li_2O	—	0.60
Characteristics.		
Fluidity (flow) (sq. cm.)	9.43	18.14
Calculated coefficient of expansion (in. × 10-7)	262	267
Actual coefficient of expansion (in. × 10-7)	274	278
Fusing temperature (deg. C.)	750	730
Under-fired temperature (deg. C.)	735	710
Reflectance, tri-amber filter	76	78
" tri-green filter	75	77
" tri-blue filter	76	77
Gloss	79	83

observed between any of the enamels fused at 850 deg. C. It is noted, however, in Table I that, while the lithium enamels showed satisfactory fusion at 830 deg. C., the non-lithium enamel was under-fired at this temperature. It is therefore suggested that the highest temperature at which slight under-fusing was detected is the best criterion for comparison. This procedure was afterwards adopted with all the enamels tested.

Tests were carried out on samples of steel which had shown fish-scaling tendencies in production. The enamelling process was modified to promote fish-scaling if possible. In all cases where fish-scaling was shown with non-lithium enamels, it was also shown in lithium enamels, although in most cases it was more delayed. Various trials were carried out, but these did not support Huppert's findings that lithium eliminates fish-scaling in steel prone to this defect. Apart from a slight difference in colour, enamels (2) and (3) showed similar characteristics and no advantage from the introduction of lithium by means of lithium manganate. Impact resistance figures have not been included in this Paper, as it was not possible to show that lithium additions had any effect on adherence.

Sheet-iron Cover-coats

The addition approximately of 1.5 per cent. lithium carbonate to the antimony-opacified cover-coats resulted in increased fluidity and gloss and a reduction in fusing temperature, together with a slight increase in reflectance and coefficient of expansion. No improvement in adherence and thermal-shock resistance was seen with either enamel. With

TABLE VI.—*Raw Batch Weights, Composition and Characteristics of Wet-process Acid-resisting Cast Iron White Enamel.*

	Enamel No. 13.	Enamel No. 14.
Raw Batch (gm.).		
Dehydrated borax	656	656
Quartz	1,644	1,644
Soda ash	538	538
Saltpetre	254	254
Titanium oxide	512	512
Fluorspar	71	71
Sodium antimoniate	325	325
Lithium carbonate	—	60
Calculated Melted Composition (per cent.).		
SiO_2	45.56	45.26
B_2O_3	12.48	12.41
Na_2O	15.58	15.47
K_2O	3.27	3.25
CaO	1.27	1.26
Sb_2O_5	6.80	6.77
TiO_2	14.18	14.08
F_2	0.86	0.85
Li_2O	—	0.65
Characteristics.		
Fluidity (flow) (sq. cm.)	5.13	8.74
Calculated coefficient of expansion (in. × 10-7)	310	314
Actual coefficient of expansion (in. × 10-7)	298	302
Fusing temperature (deg. C.)	755	735
Under-fired temperature (deg. C.)	745	725
Reflectance, tri-amber filter	69	73
" tri-green filter	69	72
" tri-blue filter	68	69
Gloss	77	86

TABLE VII.—*Effect of Fusing Temperature on Reflectance of Titanium Enamels.*

	Enamel No. 9.	Enamel No. 10.
Using tri-amber filter:		
Fused at 820 deg. C.	61	76
830 deg. C.	72	78
840 deg. C.	74	78
850 deg. C.	74	78
Using tri-green filter:		
Fused at 820 deg. C.	62	75
830 deg. C.	71	77
840 deg. C.	74	77
850 deg. C.	74	77
Using tri-blue filter:		
Fused at 820 deg. C.	62	72
830 deg. C.	70	74
840 deg. C.	73	74
850 deg. C.	73	74

the acid-resisting type, very slight over-firing was necessary to obtain complete resistance, but this was less noticeable with the lithium-bearing enamel.

Similar characteristics were shown with the titania-opacified enamels. A further indication of the reduction in fusing temperature is shown in Table VII. It appears that the non-lithium enamel does not attain its maximum reflectance until a fusing temperature between 830 and 840 deg. C. is reached, whereas the lithium-bearing enamel attains its maximum reflectance between 820 and 830 deg. C. The lithium enamel showed a slight tendency towards creaminess, and this again is indicated in Table VII, the green and amber filters showing an increase in reflectance, while the blue filter gave very similar figures.

Cast-iron Enamels

As with previous enamels, the fluidity and gloss were increased and fusion temperature reduced with

the addition of lithium. Visual examination indicated that the increase in fluidity improved the surface texture, and had a beneficial effect on pinholing and boiling, but a further study is necessary to evaluate these advantages. The lithium-bearing acid-resisting enamel showed a tendency towards creaminess.

Summary

The results of this study indicate that the addition of lithium will reduce the fusion temperature of enamels with widely different formulæ. It also increases the fluidity of the enamel, giving a smoother surface with reduction of pinholes, orange-peel effect, etc. Large-scale production has indicated that the addition of lithium has a beneficial effect in the reduction of strain lines, particularly in the high-titania enamels. The increase in gloss can be seen in most enamels by visual examination.

Although there is a fairly wide difference in the actual and calculated coefficients of expansion of some of the enamels, it is very significant that the increase in actual expansion confirms the results of the recent work which indicated the correct factor for Li_2O to be 10 or 10.5×10^{-7}.

The addition of lithium appears to have little or no influence in the colour of antimony-opacified enamels, but shows a tendency toward yellow colouration with enamels containing titanium.

Little or no effect was produced on impact, thermal shock and acid resistance.

REFERENCES.

Navias (*Jnl. Am. Ceram Soc.* 1935, 18 (7), pp. 206-10), suggests that, in respect to coefficient of expansion of glass, Li_2O is as effective as Na_2O in promoting high expansion.

Nain (*Industrie Chimique*, 1932, **19** (227), pp. 882-85), noted a reduction in viscosity and coefficient of expansion when Li_2O was added to some glasses and enamels.

Lewis (*Jnl. Am. Ceram. Soc.*, 1943, **26** (3), pp. 77-83), found that O_2L improved fusibility, gloss and opacity, produced better acid-resistance and reduced coefficient of expansion.

Waterton and Turner (*Jnl. Soc. of Glass Technology*, 1934, 18 (72)), indicated coefficient of expansion factors of 4.9 to 9.9 $\times$ 10-7 dependent on composition of glasses.

Fenton and Huppert (*Sheet Metal Industries*, 1948, **25** (259), pp. 2255-59), state that some very recent unpublished work has shown the proper factor to be 10.5 to 10.7 $\times$ 10-7.

Huppert (*Finish*, 1947, 4 (6), pp. 18-21, 60), claimed the following benefits from laboratory tests and shop investigation on lithium-bearing ground-coat enamels Possibility of fusing non-enamelling stock: increase in burning range; reduction in burning temperature and time, elimination of fish-scaling and improvement in resistance to thermal shock.

Fenton (*Amer. Ceram. Soc. Bull.*, 1948, 27 (12), pp. 492-5, deals with the various lithium compounds as smelter and mill additions. He suggests that lithium zirconate substituted for lithium titanate gives a marked improvement.

Fenton and Huppert (*Sheet Metal Industries*, 1948, 25 (259), pp. 2255-59) report on the results of plant tests using various lithium compounds in sheet-iron ground-coats and titanium cover-coats and claim more neutral whites by using lithium zirconium silicate in the smelting batch.

Cook and Essenpries (*Jnr. Amer. Ceram. Soc.*, 1944, 32 (3), pp. 114-20) detail the effect of the substitution of small amounts of lithia for K_2O and Na_2O on the properties of a titania cover-coat enamel. They claim substitution of Li_2O for K_2O resulted in increased reflectance ncreased fluidity and that colour moved towards yellow white.

A SCRIP BONUS of one 10s. share for every 10s. of ordinary stock held on April 25 is announced by the directors of John Brown & Company, Limited, the shipbuilders and engineers. Treasury consent has been obtained.

Institute of Vitreous Enamellers

Spring Conference at Bournemouth

The 1951 Spring Conference of the Institute of Vitreous Enamellers will be held at the Grand Hotel, Bournemouth, on Thursday and Friday, May 24 and 25, and the programme is given below. Members are invited to complete reservation forms obtainable from the Institute and return them to John Gardom & Company, secretaries to the Institute, Ripley, near Derby, not later than April 30.

The programme includes four technical sessions and Dr. H. W. Webb has again consented to lecture. One of the sessions has been devoted to the enamelling of cast iron. A technical sub-committee of the Institute has been appointed to investigate this subject, and it is hoped that the proposed discussion will assist this sub-committee in planning the scope and direction of its work. Unfortunately, it has not been possible to arrange a works visit in connection with this conference, but an informal dinner and entertainment has been arranged for the evening of Friday, May 25. Members' ladies are invited to the conference. Hotel accommodation should be reserved as soon as possible. In the event of difficulty in this connection, the secretaries of the Institute can provide a list of hotels adjoining the Grand Hotel.

Programme

Thursday, May 24, at the Grand Hotel, Bournemouth:—1.30 p.m., Council meeting; 3.30 p.m., Paper, "Suspension of Non-plastic Particles in Water, and Related Phenomena," by H. W. Webb, O.B.E., D.SC. (past-president); 6.30 p.m., dinner in the restaurant for members going to the theatre, and 7.45 p.m., theatre party to the Pavilion, Bournemouth.

Friday, May 25:—10 a.m., Symposium on design; Papers will be presented by Mr. A. B. Kirkbride, Mr. C. S. Beers, Mr. W. Todd, and Mr. T. J. McArthur; 1 p.m., luncheon (members and ladies) at the Grand Hotel; 2.15 p.m., discussion session on the enamelling of cast iron; 3.45 p.m., buffet tea; 4 p.m., discussion session on raw materials for enamelling, and 7.30 p.m. for 8 p.m., dinner and entertainment (members and ladies) at the Grand Hotel (informal dress).

Changes of Name

The undermentioned companies have recently changed their names. The new titles are given in parentheses.

H. L. STOCKTON, LIMITED, Birmingham (Princip Metals, Limited).

ALLOY INDUSTRIES (GREAT BRITAIN), LIMITED, London, W.1 (Aerlec, Limited).

CASTINGS, LIMITED, Walsall (Castings Limited, the new name carrying no comma).

FAIMA ENGINEERING COMPANY, LIMITED, London, W.C.2 (Byron Wholesale Suppliers, Limited).

HOLMES BROS. PAINT MACHINERY, LIMITED, London, S.W.1 (J. H. Holmes & Son, Limited).

MULTIPURPOSE INDUSTRIES, LIMITED, Effingham, Surrey (Bookham Engineering Company, Limited).

DAVID BROWN CORPORATION, LIMITED, Meltham, Huddersfield (David Brown (Holdings), Limited).

CHISWICK CONSTRUCTION COMPANY, LIMITED, Brentford, Middx (Chiswick Heating Company, Limited).

Defects in Enamelling

I.V.E., Midland Section Symposium Report

Contamination in Titanium Enamels: Introduced by Dr. G. T. O. Martin

EXPERIENCE WITH titanium-opacified enamels in sheet-iron enamelling has shown that they are very susceptible to contamination. Probably most enamellers have encountered the characteristic brown-speck defects caused by the presence of a trace of antimony-opacified frit in a titanium enamel. This can happen, for example, if a mill is not thoroughly washed when changing from the one type of enamel to the other.

After operating for some time with a titanium enamel of the orthodox type, a change was made to a more fusible titanium enamel containing lithium. While rejects from boil, strainlining, chipping and distortion showed a very marked decline, two types of defects became specially prominent, and largely offset the advantage gained. These were:—

(1) A light-blue discoloration as spots, patches or smears. This covered on re-coating; and
(2) a boil or speck defect, light-blue in colour, and accentuated on re-coating or re-firing (as in transfer application). Each speck had a blue ring round it.

Both defects were more prominent in cream enamel than in white.

Effect of Organic Materials

The blue colour suggested a reducing agent, so the effect of various organic materials which would be likely contaminents was examined. No discoloration resulted when the following materials were applied to the fired groundcoat before spraying or to the biscuit before firing; lubricating oil (from air line), butter, burnt brush hairs, tobacco, ash. The following gave blue discoloration similar to the shop defects: tea, milk, soft drinks, tobacco fragments. On the fired groundcoat these gave spots or patches, on the biscuit they gave smears. Observation showed that tea was occasionally spilt or splashed on fired groundcoats, while biscuit enamel was being handled with gloves contaminated with tea or soft drinks (it was in the summer) by failure to remove the gloves when drinking from bottles. The necessary preventive measures were accordingly taken.

Effect of Metals

The speck or boil defect, which could not be covered with a second coat of enamel, was thought to be due to an inorganic reducing agent. A likely possibility was metal specks; two metals which could be present were iron and zinc, the latter from galvanised frit-quenching tanks and slurry containers. Filings of each were mixed with the titanium enamel slurry before application, and while iron gave only minute boils and blue-black specks, zinc gave violent boiling and blue specks, with a blue discoloration round each. Zinc thus appeared to be a likely source of the blue speck defects. Other metals were tried but none gave the same result as zinc. Tin, copper and nickel were without effect; aluminium and magnesium produced very fine pinholes and specks, without boiling; lead gave brown discoloration but not boiling, while brass showed an effect similar to zinc but very much less severe. No boil or speck defects resulted from compounds of zinc, metallic zinc being necessary to produce the effect.

Zinc

A thin coat of lithium/titanium enamel was sprayed on a test-piece, and a few isolated specks of zinc placed on it. When sprayed over, dried and fired, each zinc speck produced a characteristic blue boil defect. On re-coating some of these covered but others came through in more pronounced form. This corresponded with the shop results. The non-lithium enamel produced similar defects but very much smaller, some barely noticeable. Only a few came through on re-coating. This enamel had not given trouble in the shop.

The zinc speck defect was then investigated on a quantitative basis, 2.5 milligrams of zinc dust were milled into sufficient enamel to coat 5 test-plates each 6 in. square. An average of 12 defects per sq. in. was obtained, a defect can thus arise from a millionth of a gram of zinc.

Contamination of Ground Coat

The question next arose, if zinc defects can pass from one cover coat to a succeeding one, could they pass from groundcoat to cover coat. Investigation showed that this was possible, the defects were smaller but deeper than from zinc in the cover coat. The non-lithium enamel, again, was much less susceptible, giving rather less than a third the number of defects.

Source of Zinc Defects

It was necessary to decide whether the groundcoat or the cover coat was the major source of defects. Groundcoat and cover-coat frits were washed free from any possible zinc contamination with dilute hydrochloric acid followed by water. By using the four possible combinations of washed and unwashed frits, coating a number of large production plates with slurries prepared from them and carefully examining these for blue boil and speck defects, it was found that the major source of zinc contamination was the cover-coat frit.

Precautions were taken to avoid contamination of the frit with zinc, particularly from the frit-quenching baskets, some of which had been freshly re-galvanised. The use of galvanised slurry containers and other mill-room equipment was also avoided, and the trouble was then eliminated.

Discussion

A number of sample plates illustrating the defects described were shown to the meeting, and the discussion on this defect was opened by MR. CROXTON, who asked whether control plates with non-titanium enamel were fired alongside those contaminated.

DR. MARTIN said they had never encountered the defect in enamels of other types. It was characteristic of titanium enamels containing lithium. The non-lithium titanium enamel did not give any such defect to a degree sufficient to cause rejection of a finished plate.

MR. HALLSWORTH asked if there was any indication in laboratory experiments with the new enamel.

DR. MARTIN replied that small experimental smeltings are handled on a different basis, using glass and enamelled-iron containers, etc. As usually found, the fault did not arise till the enamel was used in production. The blue rings around the specks would have been noticeable had the defect been present earlier.

MR. CROXTON asked what had been the effect encountered with metallic lead.

DR. MARTIN said metallic lead was relatively harmless; it produced a brown discoloration with a reduction effect to a much smaller degree than zinc.

MR. CROXTON wondered if any other metal had a similar action to zinc.

DR. MARTIN said the effect of zinc was two-fold: it had both a reducing and a fluxing action. Tin and nickel, for example, were harmless because they had neither of these effects.

MR. HALLSWORTH queried if the fault appeared only in the enamelling shop. Had any alterations been made in the smelting plant?

DR. MARTIN replied that the fault only appeared in the enamelling shop. No changes had been made in smelting or enamelling technique, the only change being that of the frit composition.

MR. CROXTON remarked that in the past it had been found that with titanium/antimony acid-resisting enamels certain methods in the manufacturing process gave specks in the fired enamel.

DR. MARTIN had encountered this effect only in titanium enamels containing antimony. The specks were present in the frit itself, and were due to reduction of titanium during smelting.

MR. CROXTON said the trouble was overcome by the use of better mixers.

DR. MARTIN, elaborating, said the reduced titania speck effect in the fired enamel was very definite, but it was not a boil and could be covered by a second coat. The danger of the zinc defect was that it would not cover. This was a fresh type of defect which arose when the new enamel, susceptible to zinc, was introduced. Both organic and zinc contamination defects were not confined to enamel of the company's manufacture; they could occur with commercial enamels of the lithium/titanium self-opacifying type. But whereas the first was completed after one firing, the second persisted.

Yellow Discoloration Defect: Introduced by Mr. S. Hallsworth

MR. HALLSWORTH showed a casting finished in grey acid-resisting titanium cast-iron enamel in which there was a deposition of yellow coloration in certain parts of the coating. It appeared that the yellow possibly came from the colouring oxide.

MR. LAITHWAITE said his organisation had encountered a similar trouble with a green colour. It was found that the yellow was due to alkali chromate, formed in the slurry liquor by reaction of alkali in the liquor with chromic oxide in the green colouring material.

MR. HALLSWORTH explained that there was no chromium in the grey oxide, but it might have been possible that some soluble material, other than chromate, was produced by reaction with alkaline slurry liquor.

MR. WILLIAMS said the fault certainly appeared where the spraying left the enamel wettest and concentration of the liquor would be highest at such places.

MR. LAITHWAITE said they had altered the mill liquor composition to make it less alkaline.

DR. MARTIN thought it should be possible to reproduce the effect in the laboratory under exaggerated conditions and so decide on the necessary correction to the liquor. Presumably the mill make-up contained sodium nitrite, and the possibility of some impurity introduced with this should be considered. His company had found that the quality of commercial sodium nitrite varied considerably. Cases had been observed where it gave a distinct colour in a titanium enamel.

MR. HALLSWORTH agreed that the mill additions included ½ per cent. sodium nitrite.

Boiling of Groundcoat Enamel: Introduced by Mr. Whitehouse

MR. WHITEHOUSE showed a defect in sheet-iron groundcoat having the appearance of small widespread boils. The cause was traced to products of combustion leaking into the firing zone of a continuous furnace. The trouble was avoided by firing at a higher temperature. Re-firing or cover-coat firing gave a grizzled appearance, increased by re-firing the cover coat. After a second coat the grizzle defect was still pronounced. With a good furnace, where there was no leakage of combustion products into the firing zone, all plates were free from the defect.

MR. LAITHWAITE said this defect resembled one previously encountered and called "grizzle." Some groundcoats were more susceptible than others. The fault was specific to leakage into the furnace muffle and disappeared on rebuilding the furnace.

DR. MARTIN pointed out that an interesting characteristic of the defect was that, on re-firing, it disappeared, but came back on cooling again just before the enamel solidified.

MR. PRICE said it had been found that in another furnace there was no trace of the defect. Were the components and groundcoats identical in the two cases, and was trouble experienced with all components?

MR. WHITEHOUSE replied that components and enamel as factors were eliminated by comparing enamel milled at the works with that milled elsewhere and plates pickled elsewhere with those pickled at the works. Plates fired elsewhere were good, but those fired in the faulty furnace showed the defect. The cure was to transfer groundcoat firing to another furnace.

DR. MARTIN had found a single-frit groundcoat more sensitive than a blended one; was the groundcoat a single frit or a blend of frits?

MR. WILLIAMS said it was a blend of two frits. Both a coal-fired and a gas-fired furnace had been used without the defect appearing.

DR. MARTIN asked if all the furnaces fired at the same speed, as it had been found that faster firing accentuated the defect.

MR. WILLIAMS replied that the firing times in a modern gas-fired furnace, a coal-fired static furnace and two continuous furnaces were all similar. But faster firing gave worse trouble.

A MEMBER: A similar difficulty has been encountered in an oil-fired furnace, in this case also the trouble was traced to the furnace atmosphere.

MR. WHITEHOUSE said they had examined the effect of products of combustion separately. Neither CO_2 nor SO_2 produced the particular defect; with SO_2 and water the defect was not the same, but more in the nature of a blister.

MR. SWINDELLS said his firm were at one time concerned with the possible effects of sulphur in combustion products and there had been instances where rough enamel had been obtained. With a firing time of two hours for heavy objects, bad fishscaling also resulted when combustion products were present.

MR. LAITHWAITE said investigation of the effect of the various gases present had shown that moisture was the chief culprit. Dried products of combustion had little effect. Firing of plates in a laboratory muffle showed that CO_2 produced some effect, SO_2 produced a bloom only, while SO_2 and moisture gave blisters and bloom.

MR. WHITEHOUSE reported that sulphur scum was not noticeable in their case, though gloss improved somewhat when the furnace was repaired.

MR. PRICE was of the opinion that a trace of water would accentuate sulphur scumming noticeably.

Blister Defects on Acid-resisting Groundcoat: Introduced by Mr. Laithwaite

Mr. Laithwaite showed two experimental plates coated with an acid-resisting groundcoat. On one only of these, blister defects were present. Grade of metal, slurry sample and firing conditions were the same for the two plates.

MR. PRICE asked about the effect of pickling.

MR. LAITHWAITE said the difference was due to pickling conditions. The faulty plate had been pickled under normal production conditions but kept in the laboratory for several days and was not really clean. There was reason to believe that the enamel would give a perfect result, which was obtained on the second plate. This had been pickled in the laboratory and enamelled immediately. Acid-resisting groundcoats were more sensitive to processing conditions than ordinary groundcoats, which would have covered the faulty plate without difficulty. The enameller did not always realise the tolerances which existed in his enamels. With an enamel which was sensitive, attention to pickling was always justified.

MR. WILLIAMS asked would the type of water have an effect.

MR. LAITHWAITE said there was the possibility of a concentration of salts on the metal surface which could cause corrosion of the metal on standing.

MR. WILLIAMS said that although it was a type of boil defect, this was very different from the one previously discussed.

MR. LAITHWAITE said this enamel could not be compared with an ordinary groundcoat. It was susceptible to different troubles and was far more sensitive to processing conditions.

MR. WILLIAMS thought Mr. Laithwaite was virtually applying cover coat straight on the metal.

MR. LAITHWAITE pointed out that the plate free from boiling showed scarcely-healed pinholes, this could be avoided by the use of a nickel dip.

MR. MARSHALL said it was noteworthy that both plates were extremely good on the back; was there any significance in this.

MR. LAITHWAITE said the effect was to be associated with drying conditions. The plates were dried horizontally over a gas flame. If held vertically while drying, the two sides would be the same. The temperature speed and atmosphere of drying all had an effect. The face sides of the two plates were, however, strictly comparable.

Closing the discussion, the chairman welcomed Mr. Donaldson from Falkirk who had now joined the Midland section on taking up an appointment in Birmingham. He announced that the next meeting would be a joint one with the Society of Glass Technology, the subject being "Personnel Selection in Industry" and then declared that meeting closed.

I.V.E. Winter Meeting

The Institute of Vitreous Enamellers held their one-day winter meeting at the Charing Cross Hotel, London, on March 7 at the invitation of the Southern section of the Institute. A full day's programme had been planned, starting at 11.30 a.m. with a technical session at which a Paper, "Enamelling of Hollow-ware," was read to an audience of over 70 members by Mr. K. H. Broadfield (chief chemist, Ernest Stevens, Limited). Mr. Broadfield discussed many items of general enamelling interest from the point of view of the hollow-ware manufacturer, and his Paper was followed by a very keen discussion, which would have continued well into the afternoon had the time been available.

After luncheon at the hotel, members were conveyed by special coach to the works of Frigidaire, Limited, Edgware Road, Hendon, where they were conducted on a tour of the works and were enabled to see the vitreous enamelling of refrigerator liners and other stages in the production of refrigerators. The party was most hospitably entertained to tea by the company and were afterwards returned by coach in sufficient time for Midland members to catch train connections home.

National Research Development Corporation

Report of First Year's Activities

The need for a National Research Development Corporation arose from the fact that, while the ingenuity of British inventors is second to none, adoption of the results of their discovery and invention is frequently slower in this country than abroad. The Development of Inventions Act, 1948, was intended to provide a corrective for this tendency and to this end a National Research Development Corporation was appointed on June 28, 1949. A report and statement of accounts for the year ended June 30, 1950, has recently been issued.

During the period under review, Government Departments submitted 444 inventions of which three have been accepted for development, and 40 are being exploited. Members of the public submitted 485 inventions of which 358 were rejected, three accepted for development and two are being exploited. No submissions were made by any of the industrial research organisations. Universities submitted 20 inventions of which 16 are now under active exploitation. The income and expenditure account for the year shows total outgoings of £20,581, of which remuneration of members takes £5,165; staff salaries £4,794; travelling expenses £2,709; printing, stationery, postage, etc., £1,151. Revenue from exploitation of inventions brought in £3,566.

In the course of some general comments, the Corporation point out that their terms of reference are broad and generous and that they propose to interpret them boldly by accepting responsibility for any inventive enterprise clearly in the national interest the proper sponsorship of which is genuinely unprovided for. What in fact constitutes the national interest, it is stated, has to be decided in the light of the circumstances of each particular case. There are few precedents of value, and it can only be said that the Corporation ought clearly to pay particular attention to the improvement of the efficiency and general competitive power of British industries, the securing and maintaining of export markets notably in hard-currency territories, the reduction of imports, particularly hard-currency imports, the earning of royalties abroad and the development of economically advantageous British machines, instruments, processes, and products.

Transfer to D.S.I.R.

On April 1, the Technical, Information and Documents Unit, which for a number of years has been attached to the Board of Trade, became part of the information services of the Department of Scientific and Industrial Research. For the present the unit will remain in Lacon House, Theobalds Road, London, W.C.1, where it will continue to hold at the disposal of industry the large collection of unpublished documents, interest in which has recently revived on account of the valuable information they contain on the production and use of substitute materials.

A small technical section is available to assist with the selection of material to meet specific needs, while a reading room is provided for those wishing to make a detailed study of drawings and documents. Alternatively, photocopies can be supplied at moderate charges.

T.I.D.U. will be represented at the British Industries Fair on Stand W.2 at Earls Court and Stand B.425 at Castle Bromwich.

Board Changes

MUSCHAMP, TAYLOR, LIMITED—Mr. L. V. Potter has been appointed a director.

FIRTH BROWN TOOLS, LIMITED—Mr. S. W. Rawson has reliquished his directorship.

CRITTALL MANUFACTURING COMPANY, LIMITED—Mr. Robert Small has resigned from the board.

EAGLESCLIFFE CHEMICAL COMPANY, LIMITED—Mr. C. H. Hutton-Wilson has resigned from the board.

ALBRIGHT & WILSON, LIMITED—Mr. John G. Clarke, general works manager, has been elected a director.

J. SAMUEL WHITE & COMPANY, LIMITED—Mr. J. A. Milne and Mr. Ronald Allen have joined the board.

ENGLISH CLAYS LOVERING POCHIN & COMPANY, LIMITED—Mr. L. F. Daniels has been elected a director.

HOPKINSONS, LIMITED—Mr. G. Sewell, the company's chief mechanical engineer, has been appointed to the board.

WARNE, WRIGHT & ROWLAND, LIMITED—Mr. J. P. C. Wright and Mr. Clifford Cole have been appointed directors.

CORNERCROFT, LIMITED—Mr. Sidney A. Smith has been elected to the board to fill the vacancy caused by the recent death of Mr. A. E. Hudson.

PERCY E. FISHER, LIMITED—Mr. Joseph Keir has been appointed managing director and Mr. C. G. Rope and Mr. A. W. Knight have been appointed directors.

CRITTALL-HOPE METAL WINDOWS (SOUTH AFRICA), LIMITED—Mr. G. B. Brown has been elected a director in place of Mr. E. J. Peet-Yates, who has resigned.

M. MOLE & SON, LIMITED—Mr. John William Baillie, the chairman, has resigned from the board because of differences with one of the residual legatees under the will of the late Mr. Percy A. Mole, former managing director.

THOS. FIRTH & JOHN BROWN, LIMITED—Mr. E. J. Lowe, for many years a local director and works manager, and Mr. E. Wilson Hague, a local director and general sales manager, have been elected directors of the company.

Import Licensing Changes

Many additions to the Board of Trade list of goods freely importable from all (*i.e.*, including hard currency) countries were made as from March 28. Iron and steel scrap, iron ore, and pig-iron, are among the items listed.

The full list of additional items includes the following:—

Asbestos, raw and fibre; asbestos waste; bit-metal, thermostatic; fluorspar; graphite; iron carbonate.

Iron or steel scrap fit only for the recovery of the metal; iron ore (including bog ore, but not including pyrites); iron powder (not including iron carbonyls); magnesite; manganese ore.

Metals, unwrought, the following: Beryllium, cobalt, columbium, molybdenum, titanium, tungsten.

Microdol (micronised dolomite); petroleum coke; pig-iron; platinum ores and concentrates; refractory or heat-insulating bricks, blocks, and other shapes.

Brymbo Compensation

The board of Guest Keen & Nettlefolds, Limited, announces that the compensation value of the 590,763 shares of £1 of Brymbo Steel Works, Limited, has been determined between the Ministry of Supply and the stockholders' representative at 32s. 6d. per share. The shares were not quoted on any Stock Exchange and were all held by Guest Keen & Nettlefolds, Limited, the parent company.

Personal

MR. GEORGE FOWLER has been elected president of the Association of Engineering and Shipbuilding Draughtsmen.

MR. W. E. A. REDFEARN, a special director of English Steel Corporation, Limited, Sheffield, has been re-elected president of the National Association of Drop Forgers and Stampers for a second year.

MR. CECIL MCFETRICH, a director of Bartram & Sons, Limited, shipbuilders, of Sunderland, and chairman of N.E. Metal Fabrications, Limited, Sunderland, has decided to retire from Sunderland Town Council for business reasons. He joined the council in 1942.

DR. E. C. ROLLASON, a director and research manager of Murex Welding Processes, Limited, has been appointed to the Henry Bell Wortley Chair of Metallurgy at Liverpool University. He was formerly senior lecturer in the metallurgy department of Birmingham University.

MR. F. BOWEN has been appointed to the board of Radiation Group Sales, Limited, and will be in charge of the solid-fuel division. He joined the Radiation organisation in June, 1927, as secretary of the John Wright group of Companies in Birmingham and, in 1938, transferred to the associated Company at Leeds —Wilsons & Mathiesons Limited—of which he became managing director.

MR. GEORGE KELWAY has been appointed area manager in Birmingham for A. C. Wickman, Limited, machine-tool specialists, of Coventry. He has been with the company since 1932, and for the past five years has specialised in sales in the London area. During the war he was loaned by the company to the Ministry of Supply's Machine Tool Control as technical adviser. He succeeds MR. C. R. PERKS, who is leaving England shortly to establish and manage a new branch factory at Mentone, Melbourne, Australia.

Wills

HALL, F. W., a former secretary of William Doxford & Sons, Limited, shipbuilders and engineers, of Sunderland £2,630

SWAIN, HERBERT, of West Timperley (Ches), managing director of Isaac Swain & Nephew, Limited, iron and non-ferrous metal founders, of Salford (Lancs) £21,956

ROBERTS, HAROLD, Lord Mayor of Birmingham in 1937, MP for the Handsworth Division since 1945, and a director of Fletcher, Houston & Company, Limited, ironfounders, etc., of Dudley Port, Tipton, and Lees & Sanders, Limited, gold, silver, and platinum refiners, of Birmingham £34,064

Sheffield Metallurgists, Dinner

About 30 guests attended a farewell dinner given by DR. H. LEE, of the metallurgy department of the University of Sheffield, at the Royal Hotel, Sheffield on March 22. Dr. Lee expects to leave this country later in the year to take up an important metallurgical appointment in China. The dinner also gave many of his friends an opportunity to offer their congratulations to their host on his award of the coveted degree of doctor of metallurgy, which he has received in recognition of his research work, largely concerned with the cold-working of steel. Dr. Lee has been at Sheffield for more than 13 years.

Guests at the dinner included research students from Canada, South Africa, Spain, and Finland, together with a number of "old boys," among whom were Dr. P. K. Gledhill, Mr. J. E. Worthington, and Mr. J. M. Middleton, Dr. H. K. Lloyd, Mr. D. V. Wilson, Dr. C. S. Ball, Dr. N. Stephenson, and Mr. T. Bishop. A farewell gift from Dr. Lee's friends took the form of a silver tankard.

News in Brief

GRAVEL GATE FOUNDRY COMPANY, LIMITED, have had plans approved to erect a new foundry at Alford Street, Oldham, Lancs.

NODULAR CAST IRON is now being manufactured under licence in the Muirhall Foundry, Larbert, by Robert Taylor and Company, Limited, and is being displayed in the Scottish Engineering Centre in Glasgow.

METROPOLITAN VICKERS ELECTRICAL COMPANY, LIMITED, Trafford Park, Manchester 17, have this year chosen a portrait of Miss Pat Riley, of their educational department as the adornment to the "girl" calendar, the receipt of which we acknowledge with gratitude.

SHIPYARDS and engineering works at Greenock and Port-Glasgow are stated to be experiencing the greatest boom in their history, the shipbuilders having enough work on hand to ensure full employment until at least the beginning of 1954, and orders are still coming in.

SOME Sheffield steelworks furnacemen working in intense heat spend £4 a week on beer, it was stated at Sheffield Licensing Sessions, when an application was made unsuccessfully for that city's licensing hours to be extended by half and hour to enable shift workers to have a drink after finishing work.

THE BOARD OF TRADE reminds traders that the census of distribution forms sent out at the beginning of the year should have been completed and returned by March 31. The only exemptions are for those traders who have asked for an extension because their business year ends between December 31, 1950, and April 6, 1951.

THE MAIN FRAME, complete with bearing pedestal, for a 36-in. by 24-in. sledging machine to crush ore and stone at the rate of 80 to 90 tons an hour has been successfully cast by David Brown-Jackson, Limited, Manchester. Total weight of this steel casting is 12 tons, length 10 ft. 6 in. and width 5 ft. 6 in.

A NEW FOUNDRY, which has cost over £250,000, has been opened at the works of the Sheepbridge Engineering, Limited, Derbyshire. The present range of castings will be continued, but on a larger scale. The foundry is finding employment for some 250 workers but many more men are likely to be needed at the works in the near future when further development schemes are completed.

RISING WORLD MARKET PRICE LEVELS for non-ferrous metals are reported to be providing some stimulus to the mining industry in Finland. Operations in the Nivala Nickel Mines in Ostrobothnia have now been resumed, and an effort to increase copper production is rapidly gaining momentum. In spite of the local production, Finland is threatened with a shortage of copper owing to large export commitments.

THE UNITED STATES has granted Britain an additional 19,000 tons of sulphur to meet the immediate shortage. This was announced in Washington on March 26 by the Department of Commerce. The extra supplies are part of a 30,000-ton supplementary export quota for Marshall Aid countries. Discussions on Britain's sulphur requirements began in London recently between representatives of the Board of Trade and two United States experts.

THROUGH THE GOOD OFFICES of Mr. J. J. Sheehan, a Liveryman of the Company, a visit has been arranged for members of the Livery of the Worshipful Company of Foundries to visit certain foundries in the Midlands (including an evening at the Shakespeare Memorial Theatre) on April 24 and 25. The itinerary to be followed includes visits to the National Foundry College at Wolverhampton, the Birmid Industries group of producers and the Imperial Foundry Company, Limited, at Leamington Spa.

Contracts Open

The dates given are the latest on which tenders will be accepted. The addresses are those from which forms of tender may be obtained. Details of tenders with the reference B.P.D. or C.R.E. can be obtained from the Commercial Relations and Exports Department, Board of Trade, Thames House North, Millbank, London, S.W.1.

BELFAST, April 10—Special axle box bearings, universal milling machine, etc., for the City Council. The Transport Department, Sandy Row, Belfast.

BELFAST, April 12—Copper fittings, compo pipe and pig lead, purifier grids, iron castings, spare parts for water gas plant, etc., for the City Council. The Gasworks, Ormeau Road, Belfast.

BRADFORD, April 7—Cast-iron sludge filter presses, sludge pumping set, fume extraction plant, sludge screening plant, etc., for the City Council. The Sewage Works Engineer and Manager, Esholt Hall, near Shipley.

CRICKHOWELL, May 16—Provision and laying of approx. 2,100 yds. of 6 in. and 9 in. cast-iron pipes, etc., for the Rural District Council. Thomas & Morgan & Partners, civil engineers, 23, Gelliwastad Road, Pontypridd. (Deposit £3 3s.)

DERBY, April 14—Approximately 450 hydrant casings and covers, etc., for the County Council. The Water Engineer and Manager, 1, Tenant Street, Derby.

EPPING, April 20—Gully grates and frames, etc., for the Urban District Council. Mr. H. J. Mead, council's surveyor, 91, High Street, Epping.

GLASGOW, April 9—Cast-iron manhole covers and frames, bolts, nuts, electric cables, etc., for the City Council. The Office of Public Works (Room 81), City Chambers, Glasgow.

HORSHAM, April 24—Contract No. 5—Providing and laying approx. 26,300 yds. of 12 in., 15 in., and 18 in. dia. spun-iron pipes, etc., for the North-West Sussex Joint Water Board. Edward Sandeman, Kennard & Partners, consulting engineers, 1, Victoria Street, London, S.W.1. (Deposit, £5 5s.)

ISLE OF AXHOLME—Supply and laying of about 1,200 yds. of spun-iron pumping mains, etc., for the Rural District Council. Mr. J. H. Haiste, 4, Queen Square, Woodhouse Lane, Leeds, 2 (deposit, £3 3s).

LETTERKENNY, April 9—Supply and installation of one sectional cast-iron boiler, for the District Mental Hospital. The Clerk's Office, District Mental Hospital, Letterkenny.

WYCOMBE, April 9—Furnishing and laying of about 3,000 yds. of 4-in. spun-iron pumping mains, etc., for the Rural District Council. Balfour & Sons, consulting engineers, 131, Victoria Street, Westminster, London, S.W.1 (deposit, £5).

Export Licensing Control

The Board of Trade announced that from March 31, 1951, export licences are required for all destinations for oleic acid, tungsten carbide and cobalt metal powders and mixtures and kinetheodolites; and the item "tanks, armoured cars, armoured transport vehicles and component parts thereof" is amended to read "tanks, armoured cars, and all other armoured vehicles and component parts thereof."

From the same day, licences are required for export to most destinations (broadly, all countries other than Commonwealth and United States) of carbon and graphite in specified forms, further plastic material, certain siloxanes, germanium and its compounds, alloys containing 20 per cent, of bismuth, drums and barrels made of corrosive-resistant metal, tanks of stainless steel, steel ball and roller bearings, underwater cutting electrodes, floating docks, heat exchangers of certain types, specified machinery and plant for water treatment, certain metal-working tools, types of a cross-section of 7 in. or more, some outboard and other types of internal combustion marine engines, marine propellers, specified items of electronic equipment, marine gyro-compasses, and hydrazine and its salts.

Rape seed oil, and swords and lances will be exempt from export licensing control.

MR. D. L. CAMPBELL, M.C., has been appointed a director of the Electric Furnace Company, Limited.

Increases of Capital

The following companies are among those which have recently announced details of capital increases:—

F. E. CALLOW (ENGINEERS), LIMITED, Wolverhampton, increased by £1,000, in £1 shares, beyond the registered capital of £5,000.

OXLEY ENGINEERING COMPANY, LIMITED, Leeds, increased by £50,000, in 5s. ordinary shares, beyond the registered capital of £200,000.

H.E.M. (CAMBRIDGE), LIMITED, agricultural engineers, etc., increased by £1,000, in £1 ordinary shares, beyond the registered capital of £3,000.

TOWNSON & COXSON, LIMITED, brassfounders, of Birmingham, increased by £20,200, in £1 shares, beyond the registered capital of £15,000.

"DEE-KAY" ENGINEERING COMPANY, LIMITED, Shipley, increased by £3,000, in £1 ordinary shares, beyond the registered capital of £3,000.

GASCOIGNES (READING), LIMITED, dairy engineers, etc., increased by £100,000, in 2s. ordinary shares, beyond the registered capital of £100,000.

ALMEX, LIMITED, smelters, metal refiners, etc., of Birmingham, increased by £10,000, in £1 ordinary shares, beyond the registered capital of £5,000.

ALUMINIUM DIE CASTINGS (BIRMINGHAM), LIMITED, increased by £15,000, in £1 ordinary shares, beyond the registered capital of £10,000.

BROWNHILLS SMELTERS, LIMITED, Brownhills (Staffs), increased by £20,000, in 5,000 6 per cent. cumulative preference and 15,000 ordinary shares of £1 each, beyond the registered capital of £30,000.

EDGE & SONS, LIMITED, engineers, ironfounders, etc., of Shifnal (Salop), increased by £70,000, in £1 shares, beyond the registered capital of £30,000. At June 30, 1950, British Ropes, Limited, held 19,680 shares out of 19,980 issued.

HUNT & MITTON, LIMITED, engineers, brassfounders, etc., of Birmingham, increased by £25,000, in 5,000 ordinary, 17,902 5 per cent. non-cumulative redeemable preference shares and 2,098 unclassified shares of £1 each, beyond the registered capital of £25,000.

MOTOR GEAR & ENGINEERING COMPANY, LIMITED, Chadwell Heath (Essex), increased by £50,000, in 30,000 redeemable cumulative 6 per cent. preference shares of £1 and 80,000 ordinary shares of 5s. each, beyond the registered capital of £20,000.

ALSTON FOUNDRY COMPANY, LIMITED, Alston (Cumberland), increased by £50,000, in £1 ordinary shares, beyond the registered capital of £25,000. At September 6, 1949, Steel & Company, Limited, held 24,998 £1 ordinary shares out of 25,000 issued.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, London, E.C.4, increased by £5,750,000, in £1 ordinary shares, beyond the registered capital of £250,000. This increase is for the purpose of acquiring part of the undertaking of Associated Electrical Industries Limited.

Magnesium to be Controlled

Responsibility for the supply and distribution of all virgin magnesium in the United Kingdom from May 1 will be that of the Ministry of Supply. To enable the Ministry to assess the requirements of industry consumers of virgin magnesium are required to provide information of stocks at March 31, consumption during the first quarter of 1951, and estimated requirements in April and May. This information is required by April 10 and similar information will subsequently be required each month.

Known consumers will receive a form for this purpose. Those not receiving the form should apply to:—Ministry of Supply, M.2. Branch, Room 948, Shell Mex House, Strand, London, W.C.2.

During April consumers can obtain their supplies, as far as stocks permit, from Magnesium Elektron, Limited, Clifton Junction, Manchester. They may apply direct or, if preferred, through the Ministry of Supply.

THE BOARD OF TRADE has announced the appointment of Sir Colin S. Anderson as a member of the Council of Industrial Design. Sir Colin is a director of Anderson, Green & Company, Limited, shipowners, and of various other companies.

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Stanton Machine-cast Pig Irons are clean-melting, and economical in cupola fuel.
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Raw Material Markets

Iron and Steel

Expansion of pig-iron production is not yet possible and current outputs fall short of requirements. The best that can be said is that the position has not suffered further deterioration, but heavy engineering foundries are involved in difficulties arising from the reduced deliveries of hematite and low- and medium-phosphorus irons. Surprisingly, small tonnages of refined iron are still being licensed for export, but production of No. 3 foundry iron is too limited to permit of unrestricted sales, and deliveries are mainly directed to establishments in direst need.

France has replaced Belgium and Luxemburg as the principal source of such supplies of steel semis as continue to reach British consumers. In fact, imports during the first two months of this year were almost equal to the corresponding figures for January-February of last year, and home-produced material has hitherto been coming to hand fairly regularly. If, however, the drop in steelmakers' outputs is of more than very brief duration, there must be unfavourable reactions in the re-rolling industry, where the adequacy of supplies is already the chief anxiety.

The market for all descriptions of finished steel products has lost none of its buoyancy. Many big oversea inquiries are circulating, and it is going to be difficult to reconcile the conflicting claims of an export expansion programme with the heavy demands of home users and the requirements of the arms drive.

Non-ferrous Metals

As from Sunday last, increased selling prices for copper, lead, and zinc were introduced by the Ministry of Supply. Electrolytic copper was increased by £8 to £210 per ton, good soft pig-lead went up by £24 to £160 per ton, and good ordinary brand zinc was increased by £9 to £160 per ton. All prices are based on delivery to buyers' premises. Discounts and premiums and charges for forward delivery, where applicable, remain unaltered, and the Ministry's buying price for rough copper is also unchanged.

The Ministry stated that the increases for lead and zinc were necessary because of the higher prices which the Ministry has to pay for some of its supplies. The advance in the copper price was attributed to higher costs such as freight and handling charges.

A new Order bringing the maximum prices of non-ferrous scrap into line with the new selling prices of virgin copper, lead, and zinc came into operation yesterday (Wednesday). The new prices are given on this page.

Last week brought news that the Ministry of Supply was taking over responsibility for the supply and distribution of magnesium in this country. It was also stated that monthly announcements of allocations of copper, lead, and zinc, which have been made to industry by the Ministry for the past few months, have been suspended. In future, announcements will only be made when a change has to be indicated, and it may be presumed that allocations for April are unchanged from March.

The absence of any decision on the vexed question of international allocation of tin at the Washington talks was interpreted bullishly on the London tin market on Friday, when the price of spot metal rose substantially.

Metal Exchange official tin quotations were as follow:—

Cash—Thursday, £1,230 to £1,240; Friday, £1,255 to £1,265; Monday, £1,335 to £1,340; Tuesday, £1,265 to £1,270; Wednesday, £1,245 to £1,250.

Three Months—Thursday, £1,155 to £1,160; Friday, £1,195 to £1,200; Monday, £1,260 to £1,270; Tuesday, £1,200 to £1,205; Wednesday, £1,195 to £1,200.

Non-ferrous Scrap Prices

The Non-ferrous Metals Prices (No. 3) Order (S.I. 1951, No. 550) came into operation yesterday (Wednesday). The Order brings the maximum prices of non-ferrous scrap into line with the new selling prices of virgin copper, lead, and zinc.

The new scrap prices, per ton, are:—

LEAD—Remelted, containing by weight not less than 96 per cent. of lead, £147.

ZINC—Remelted, £154; hard spelter, £144; secondary alloys to BSS No. 1141, £175.

COPPER SCRAP—Clean bright untinned wire and commutator bar, £198; clean bright wire tinned, £193; firebox cut to crucible size, £193; firebox not cut, £188; No. 1 wire, £183; clean heavy, £177; No. 2 wire, £177; braziery, £155.

LEAD SCRAP—Cable sheathing, £146; other than cable sheathing and containing by weight not less than 96 per cent. of lead, £139.

ZINC SCRAP—Alloy die-castings free from inserts, £154; cuttings, £134; alloy die-castings not free from inserts, £127.

ADMIRALTY GUNMETAL SCRAP—In any form not less than 9 per cent. tin and not more than 0.5 per cent. lead, £242.

COMMERCIAL GUNMETAL SCRAP—In any form, £202.

CUPRO-NICKEL SCRAP—70/30 process scrap, £226; 70/30 used condenser tubes, £186; 80/20 process scrap, £206.

GILDING METAL SCRAP—In any form, £188.

BRASS SCRAP—QF cases free from primers, £183; QF cases not free from primers, £177; SAA cases mechanically treated or fired, £173; SAA cases muffled or furnaced, £167; cuttings, £173; rod and fuse scrap not burned, £163; swarf, £153; heavy, £148.

Members of the Federation of Secondary Light Metal Smelters, with the approval of the Ministry of Supply and with the object of stabilising price levels, have decided to adopt a range of maximum selling prices for their alloys. This measure follows the introduction of the Aluminium Scrap Prices Order, 1951, and has been taken because there is no similar Order for secondary aluminium alloy ingots.

As from Monday next, the following will be adopted as the maximum prices for the undermentioned alloys, delivered to buyers' works:—LM1, £128 per ton; LM2, £145; LM4, £132; LM6, £155; deoxidising sticks, 85/90, £115. The prices of other alloys will be related to the above.

These maximum prices are based on the present prices of raw materials and current production costs. It is hoped that consumers will co-operate with the federation in its endeavour to stabilise selling prices at a reasonable level.

Cuts in Copper and Zinc Exports

In view of the "extreme scarcity of copper and zinc," the President of the Board of Trade has made a further cut in the rate of export of semi-manufactures of copper and copper alloys. For the second quarter such exports will be limited to approximately half the rate prevailing in the first six months of 1950. The Board of Trade announces that all applications to export will be considered on their merits, and due weight will be given to "conversion value," to the established pattern of trade, and to the importance of end-use.

Before the end of June a further announcement will be made about future shipments. Exports of semi-manufactures of zinc will be permitted "only in exceptional circumstances."